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AUTHOR Gerling, Max O., Ed.
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ABSTRACT

The conference focused on problems and issues confronting collegiate mathematics educators in the preparation of preservice teachers and the assisting of inservice teachers. Five invited presentations are included in this document, plus reports from 15 discussion groups. Three of the presentations focused on inservice training on problem solving, (Katherine Pedersen and Jerry Becker), a survey on computer use in Wisconsin elementary schools (Lynda Thomas, Linda Thompson, and Linda Gilbert) and a plan for testing problem solving in Illinois (Mervin M. Brennan and Wendall A. Meeks). Discussion groups focused on such topics as the role of microcomputers, mathematical content, diagnosis, retraining, research, inservice education, mathematics clinics, student recruitment, teaching strategies, field experiences, and mathematics anxiety. Finally, a talk by Eugene D. Nichols on problem solvers is summarized, and handouts from a presentation by Phares G. O'Daffer on ideas for teaching problem solving to prospective teachers are included. (MNS)

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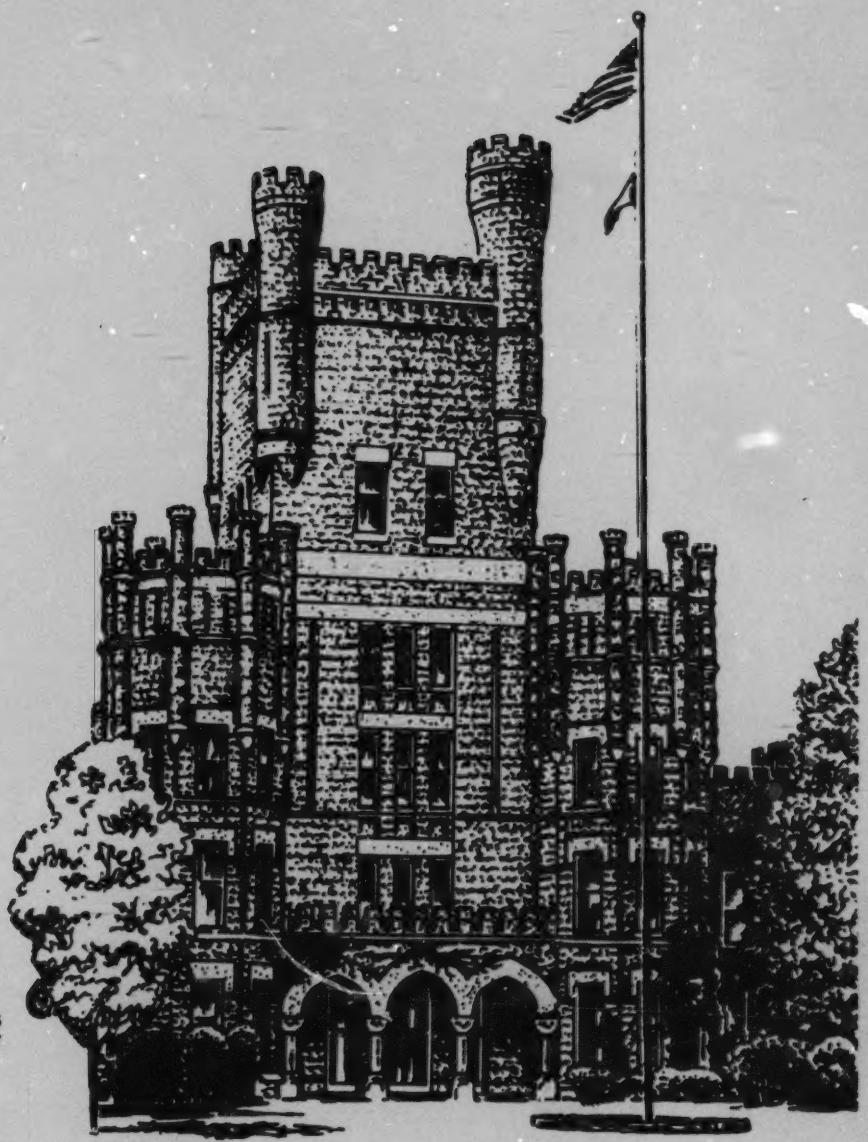
# PROCEEDINGS OF THE FOURTH MATHEMATICS METHODS CONFERENCE

**Held**
**June 28 — 30, 1984**
**on the campus of**
**Eastern Illinois University**
**Charleston, Illinois**



**Edited by**
**Max O. Gerling**

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# INTRODUCTION

The Fourth Mathematics Methods Conference was held at Eastern Illinois University on June 28-30, 1984. The conference began with exactly 90 registrants from 54 educational institutions mainly in the midwest. Successful conferences at the University of Northern Iowa in 1978, at Illinois State University in 1980 and at Ball State University in 1982 provided a firm foundation for the continuing focus on problems and issues confronting collegiate mathematics educators in the preparation of preservice teachers and the assisting of inservice teachers.

The conference began on Thursday evening, June 28, with an opening address by the president of the National Council of Teachers of Mathematics, Dr. F. Joe Crosswhite. Professor Crosswhite's presentation was entitled: "Alternative Contexts for Methods Instruction: Strengths and Limitations." He gave a description of ways that he and colleagues at the Ohio State University have worked on methods in the context of early field experiences, in connection with studies in the foundations of education, in shadow seminars accompanying mathematics content courses, in the combined content and methods courses, during student teaching, and in methods courses independent of any related context. He discussed the strengths and limitations of these alternatives, giving an historical perspective from his experience at the Ohio State University. His discussion was rich with anecdotal evidence which touches the personal experience of many of the conference participants. His masterful presentation set the tone for a highly successful conference on the following two days.

Following the opening address there was a reception for all participants at the Tarble Arts Center of Eastern Illinois University.

This being the year of the Fifth International Congress on Mathematical education in Adelaide, Australia, an international theme was chosen for the conference. The U.S. National Coordinating Center of the Second International Mathematics Study agreed to participate in the conference and for their support we are deeply indebted. Eight sessions were presented by participants from the Second International Mathematics Study on Friday, June 29. The results presented at these sessions were made publicly available at a National Conference held September 24-26, 1984, at Allerton Park near the University of Illinois at Urbana-Champaign. A copy of the national results was mailed with these Proceedings of the Fourth Mathematics Methods Conference to all conference participants.

Friday's sessions from the Second International Mathematics Study will simply be listed here by title and presenter(s) since the content is included in the September 1984 Summary Report. Dr. Kenneth J. Travers, Director of the U.S. National Coordinating Center, the Second International Mathematics Study, University of Illinois at Champaign-Urbana, gave a general session to begin the day: "Overview of the Second International Mathematics Study." This general session was followed by seven presentations on specific parts of the study. Dr. Thomas J. Cooney of the University of Georgia presented "The International Scene in Teaching Eighth Grade Mathematics." Dr. Jane O. Swafford of Northern Michigan University spoke on "What Teaching Methods do U.S. Eighth Grade Teachers Use?" Dr. John A. Dossey of Illinois State University discussed "Twelfth Grade U.S. Precalculus Mathematics: Achievement, Curriculum, and Questions." Dr. F. Joe Crosswhite of the Ohio State University gave "Implications for Teacher Education from the Second International Mathematics Study." Dr. John LeDuc of Eastern Illinois University analyzed "Twelfth Grade U.S. Calculus: Achievement and Curriculum." Dr. Avrum I Weinzweig of the Univeristy of Illinois Chicago spoke about "Interaction between Teaching Styles and the Measurement of Student Achievement (International Perspective)." Floyd Downs of Hillsdale

High School in San Mateo, California delivered "Classroom Processes-the Link between the Intended and the Attained Curriculum."

In addition to the presentations made by participants from the international study there were three other invited presentions on Friday about projects of current interest. The reports of these three presentations—by Pederson and Becker, Thompson, and Brennan—are included in full in these proceedings.

A third type of session on Friday's program was the discussion group. There were fifteen discussion group sessions based on replies from a preliminary questionnaire sent in January to about 300 potential participants. The topics with the most indicated interest were chosen for discussion with discussion leaders and session recorders being taken largely from the volunteers of those responding. Summaries of all fifteen of these discussion groups are included in these proceedings.

After the sessions on Friday a barbecue was held at Fox Ridge State Park near Charleston. This provided an opportunity for informal discussions, relaxation, and socializing which continued at a reception at the Gerlings'.

Saturday morning's activities centered around problem solving with presentations by Dr. Phares O'Daffer of Illinois State University and Dr. Eugene D. Nichols of the Florida State University. Dr. O'Daffer's handouts are included in full in these proceedings. Dr. Nichols' presentation is summarized by a compilation of reports by participants earning credit for the conference.

Besides thanks to those already mentioned, appreciation must also be expressed to the Office of Continuing Education for their tireless work in the logistics involved in managing the conference. Particular thanks are due Dr. Carol Holden, the director of the Office of Continuing Education, for her personal interest and work. Many compliments were made by conference participants verbally and later in correspondence commenting on the high quality of the program, hospitality, food, weather, and almost every aspect of the conference. Thanks are also due others in the Office

of Continuing Education: to Don McKee and Jan Calhoun for their work and to Bonnie Finley for the proficient typing of these proceedings. Thanks are also due the Mathematics Department headed by Dr. A. J. DiPietro, and to the Dean of the College of Arts and Sciences, Dr. Jon Laible, for their support in many ways ranging from secretarial help and supplies to moral and monetary support. Thanks also to Scott Foresman Publishing for a monetary contribution. And last, but not least, to Dr. John LeDuc, co-director of the conference, go my heartfelt thanks for his generous contribution of time and talent needed to run such a conference.

*Max O. Gerling*
Eastern Illinois University

# REPORT OF A PROJECT ON INSERVICE TRAINING IN THE TEACHING OF PROBLEM SOLVING

Katherine Pedersen
Jerry Becker
Southern Illinois University
Carbondale, Illinois

During the 1983-84 academic year, Southern Illinois University, Carbondale, with funding from the Illinois Board of Education, sponsored the project "Integrating problem solving into mathematics teaching." Twenty secondary mathematics teachers participated during the fall semester, and twenty elementary teachers participated during the spring semester. The participants were chosen on the basis of application and letters of recommendation. Geographical area and public/non-public school affiliations were taken into consideration. Junior high teachers (6, 7, & 8th grade) participated in both.

The teachers received 50 hours of classroom instruction throughout the semester. At the beginning of each semester, the group participating met for an intensive session which included an overnight stay in Carbondale. All other sessions were on Saturdays from 9:00 to 5:00. The objectives of the project included the following:

That the participants

1. a. learn a problem solving approach to teaching mathematics;
   b. experience using a problem solving approach in mathematics teaching.
2. be capable of implementing a problem solving mode of instruction in the classroom.
3. acquire problem solving materials suitable for classroom use.
4. learn the rudiments of programming in PASCAL and Papert's Turtle Geometry (LOGO).
5. experience using the microcomputer as a tool in problem solving.

**Problem Solving Method**

Problem solving was viewed as involving four phases (Burton, 1979):

1. Getting into the problem (Entry)
2. Solving the problem (Attack)
3. Reviewing the solution (Review)
4. Generalizing the problem (Extension).

Each of the four phases can be characterized by certain questions. These were related to student behavior by the following:

Phase 1: Entry . . . . . Getting into the Problem

| | |
|---|---|
| Does the problem solver read the problem and ask:<br>(i) What does the problem tell me?<br>(ii) What does the problem ask me?<br>(iii) What can I introduce to get started?<br>This leads to: extracting information, exploring the problem, making and testing guesses, trying particular cases, and generating data. | Here the problem solver is trying to understand what the problem is about; she/he is also trying to clarify what needs to be done. |

Phase 2: Attack . . . . . Solving the Problem

Does the problem solver begin to consider how to resolve the problem by asking:

(i) Can I organize the data?

(ii) Can I make corrections?

(iii) Can I find a pattern?

(iv) Can I make a generalization?

(v) Can I focus on one aspect of the problem?

(vi) Can I eliminate possibilities?

(vii) Can I change my view of the problem?

(viii) Can I reduce the problem to a simpler one?

Here the major thinking activity is directed towards resolving the problem; that is, getting ready to do something substantial. The problem solver may (and frequently does) get stuck! Ways of getting unstuck must be explored (Note: knowing that one is stuck is the first step in getting unstuck). There are a variety of actions which can be taken to proceed.

Phase 3: Review . . . . . Reviewing the Solution

Does the problem solver reflect on the resolution found and ask:

(i) Is the solution acceptable?

(ii) Does the result check favorably with the information in the problem?

(iii) Is the result reasonable?

Once the problem solver begins to feel that the problem is resolved, or nearly so, then it is time to check whether the resolution is, in fact, correct; if not, the solver returns to the entry phase. If, on the other hand, the resolution seems acceptable after checking against the conditions of the problem, then the problem solver proceeds to the next phase.

Phase 4: Extension ..... Generalizing the Problem

| | |
|---|---|
| Does the problem solver consider the following kinds of questions:<br>(i) What can I learn from the resolution?<br>(ii) Can I extend the resolution?<br>(iii) Can I think of similar (isomorphic) problems?<br>(iv) Can I extend the resolution to a class of problems? | Problem solving is an ongoing process—resolution of a problem is achieved, it is time to search out whether the problem resolution can lend to other problems and their resolution. Such activity may lead towards developing creativity, independence, and imagination. When students experience this, they begin to sense or feel that they have control over a situation and this, in turn, leads to self-confidence. |

**Activities**

The participants were introduced to problem solving by a hands-on approach. During the intensive session, the project directors presented non-routine problems and modeled the four phase approach to problem solving. As the sessions continued, participants working in small groups, as well as individually, presented "resolution" of non-routine problems, emphasizing the four phase approach to problem solving. Summary statements of problem resolution reviewed specific questions representative of each of the four stages.

Solutions to many problems involved the use of the microcomputer as a tool in problem solving. Participants teaching secondary level mathematics received instruction in PASCAL; elementary teachers received instruction in Papert's Turtle Geometry. The project directors delivered the instruction emphasizing the philosophy that programming and the microcomputer are tools in problem solving and not ends in themselves.

At each session, the participants were given 10-15 non-routine problems to

solve for the next session. Solutions were to be written in a two column format: one column for a diary of thoughts during the problem-solving process and the other for the relevant mathematics. Solutions involving the microcomputer included a listing of the program as well as a computer printout if the participant had access to a printer. Solutions to problems were discussed at the next session.

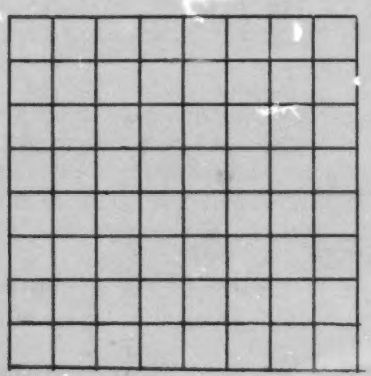
Examples of problems which worked especially well with secondary teachers were:

1. In a certain football game, a team can score only 3 or 7 points at any one time. What is the largest number which could not be a team score in this game?

2. Suppose p, q, r, and s are positive real numbers. Prove the inequality

$$\frac{(p^2 + 1)(q^2 + 1)(r^2 + 1)(s^2 + 1)}{pqrs} \geq 16$$

3. How many squares?



4. Pick any natural number. Is it even or odd? If even, then divide it by 2. If odd, then multiply it by 3 and add 1. Take the result. Is it even or odd? If even, then divide it by 2. If odd, then multiply it by 3 and add 1. Take the result. Etc. Will the process ultimately always get to 1?

5. Two female mathematicians were out for a walk. In answering the question of how many children she had, one of the mathematicians replied that she had three children and that the product of their ages was 36. Walking further, she commented that the sum of the childrens' ages was "that house number." When informed by her walking companion that the ages of the children were still not known, she replied, "Oh, the oldest is at her grandmother's." "O.K.," said her companion. "Now I know the ages of your children."
QUESTION: What are the ages of the children?

6. Three boxes each contain a number of billiard balls. One box contains only even-numbered billiard balls, one box contains only odd-numbered billiard balls, and the third box contains a mixture of odd- and even- numbered billiard balls. All of the boxes are mislabeled. By selecting one ball from one of the boxes, can you correctly label the three boxes? Why or why not?

Examples of problems which worked especially well with elementary teachers were:

1. The favorite sports of Brian, Horace, Ian, and Tammy are baseball, hiking, ice-skating, and tennis. No person's name begins with the same letter as his or her favorite sport. Tammy and Horace do not like team sports. Horace and Brian do not like cold weather sports. What is each person's favorite sport?

2. Place parentheses to make the equation true:

$$36 \div 4 + 5 - 1 + 2 \times 3 + 12 \div 3 + 1 = 6$$

3.

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

In the ten cells above inscribe a ten digit number such that the digit in the first cell indicates the total number of zeroes in the entire number; the digit in the cell marked "1" indicates the total number of 1's in the number, and so on to the last cell, whose digit indicates the total number of 9's in the number. Zero is a digit; the number is unique.

4. Three boxes each contain a number of billiard balls. One box contains only even-numbered billiard balls, one box contains only odd-numbered billiard balls, and the third box contains a mixture of odd- and evennumbered billiard balls. All of the boxes are mislabeled. By selecting one ball from each of the boxes, can you correctly label the three boxes? Why or why not?

5. Imagine that you have a cup of coffee and a cup of milk, with equal amounts of liquid in each cup. You transfer a large spoonful of milk from the cup of milk to the cup of coffee, stir until the milk is mixed thoroughly and evenly with the coffee. Then, exactly the same spoonful-amount of the mixture is transfered back to the milk cup. Which statement is true?
   1. There is more milk in the coffee cup than coffee in the milk cup.
   2. There is more coffee in the milk cup than milk in the coffee cup.
   3. The amount of milk in the coffee cup is the same as the amount of coffee in the milk cup.

6. Use LOGO to illustrate some concepts from transformational geometry.

**Evaluation**

Homework solutions were mailed to the graduate assistant, a mathematics graduate student with high school and small college teaching experience, by the Monday prior to the next Saturday session. The graduate assistant reinforced "good" problem-solving behavior and suggested alternatives to non-productive habits. She also suggested alternative strategies, possible extensions, and encouraged participants to look at such by appropriate questions on the students' papers.

No specific grades were ever given. A summary of each student's problem solving progress was prepared for the co-directors and received prior to the next session. Particular concern was paid to the diary of thoughts which ranged from terse and non-revealing to statements of fun, frustration, success, etc.

Each group of participants was given a pre-test and a post-test. Each group also prepared specific microcomputer related projects. The elementary teachers also prepared material relative to a method for implementing a problem solving in the classroom.

**Implementation**

Participants began to implement problem solving activities in the classroom using the Monday - Friday approach: problem presented on Monday and solutions discussed on Friday. Participants were encouraged to adapt this model to fit the needs of their students and the classroom schedule. A written record of each problem presented, format used, solutions received, and student reaction was kept by each participant and was mailed to the graduate assistant as part of the homework assignment.

At each session, the participants discussed their classes' problem solving behavior and shared successes and failures and suggestions with each other. Several anecdotes were always shared: it was a pleasure to have the positive affective outcomes to problem solving described so vividly!

Several other methods of implementation were presented. Among these:

secondary teachers looked at a problem solving strategy for teaching "regular" classroom topics; elementary teachers were introduced to the problem solving lesson plan format of Randy Charles and others. For a final project, each elementary teacher prepared and tested in the classroom at least three such lesson plans.

---

## Reference

Burton, Leone. The skills and procedures of mathematical problem solving project. Polytechnic of the South Bank, London, England, 1979.

**NOTE:** The activity which is the subject of this report was supported in whole or in part by the United States Department of Education. However, the opinions expressed herein do not necessarily reflect the position or policy of the United State Department of Education, and no official endorsement by the United States Department of Education should be inferred.

# SURVEY OF WISCONSIN ELEMENTARY SCHOOL COMPUTER USAGE AND TEACHER COMPUTER LITERACY

by Lynda Thomas, Linda Thompson, Linda Gilbert
Carroll College, Waukesha, Wisconsin

## Purpose of Study

With the increasing use of microcomputers in elementary schools it is becoming imperative to examine the implications of this use on elementary education preservice programs. We decided that as one way to find out what future teachers will need to know about computers, we would ask inservice teachers what they are finding they need. Specifically, we wanted to find out the following things:

1. What is the current level and nature of computer use in Wisconsin elementary schools?
2. What computer skills do inservice elementary teachers view as being most necessary to them?
3. What is the level of present teachers' computer skills and how have they acquired these skills?
4. What recommendations have inservice teachers concerning software and hardware?

## The Survey

We sent 415 packets of questionnaires to randomly selected elementary schools in all school districts in Wisconsin. In a letter to the principal of each school, we asked that he/she distribute questionnaires to four teachers of varying grade level and with varying degrees of experience.

We received responses from approximately 550 teachers from 180 schools across the state. Since schools and teachers presently using computers might have

had a tendency to respond more often to this type of survey, we feel we must consider this as a source of possible error in our findings.

**The Results**

**Teachers' Opinions on Computer Use**

The first obvious conclusion to be made from the comments on the questionnaires which were returned was that teachers have a wide variety of opinions on how and how much computers should be used in the elementary schools. Some teachers who were strongly in favor of computer use in the elementary classroom such as the two teachers quoted below.

> "I believe we should have 1 computer per classroom. All teachers shculd be trained (for credit & increments) in computers. Parents and students expect us to know more than they do about computers! I agree!"
>
> "I'm having my students (grade 5) do a set of tasks to earn different levels of computer licenses. There are 5 levels from Tenderfoot to Master. The kids are so enthused!"

Other seriously questioned the need for computers in their classrooms.

> "I really don't feel it's necessary in the elementary school to have the kids work on computers. They should be spending their time learning the basics. They can be exposed to computers in jr. high and high school.
> I do not use the computer or have my children use it because I feel that there are more important concepts for them to work on at this point in their educational life."
>
> "Maybe my head is in the sand, but I really feel that the educational uses of microcomputers for grades K-12 have been way oversold. I have been told by a U.W.-P. professor that 95% of the K-12 programs are for drill and practice. Considering the cost of computers, this seems to be a waste of educational dollars. Drill and practice can be done in equally good ways without computers.
> Also, the idea that we're moving into a computer world does not justify a big expenditure of education dollars on microcomputers. My understanding is that computer jobs are becoming less and less available. Future projections for these jobs are not great. Computers are also becoming more user friendly. While the use of computers will increase in the future I do not see the ability to program a computer as a necessary skill for high school graduates."

Still others, while not totally rejecting computer use, had questions about it such as the following.

> "Will computers make students more unlikely to work and research things for school if it isn't easily obtained, i.e., instantly, on a computer?"

"(I am) . . . open to new knowledge, methods, but skeptical of usage and quantity of use in student-centered classrooms."

Other teachers had specific comments on particular aspects of computer usage and access.

"I believe all schools should develop 'Computer Centers' staffed with trained personnel. It is extremely difficult for a classroom teacher to use computers with the entire group."

"Students in my classroom are not given any type of computer game or program to use that has a 'search and destroy' activity. I would not purchase software that even remotely suggests that any living thing is being annihilated."

A good response rate with such a survey method is 25% and the large response rate to this questionnaire (43% of the schools) was an indicator that teachers are certainly concerned about the use of computers in schools and have given the issue considerable thought.

## Computer Usage by School

To ascertain computer usage in Wisconsin schools we asked all participants how many microcomputers and how many terminals connected to mainframe computers their school had. We also listed seven common computer usages and asked in which of these ways computers were used in their school. We formed a composite of computer use in a school by combining the replies made by its different teachers.

In tallying results we divided the schools into three categories: large schools (over 500 students), middle-sized schools (300-500 students), and small schools (under 300 students). (See Table 1.)

Concern has been voiced that schools are not making much use of the computers facilities they possess but overall that does not seem to be borne out in our study. Eighty-eight percent of the schools reported students using commercial software and 85% reported teacher demonstration of software.

When the individual responses of teachers regarding their own computer use were analyzed, it became apparent that the teachers surveyed did not feel

Table 1. School Computer Use

| Usages | Large Schools (28) | | Mid-sized Schools (88) | | Small Schools (64) | | All Schools (180) | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| 1. Commercial software demonstrated by teachers | 25 | 75% | 81 | 92% | 51 | 80% | 153 | 85% |
| 2. Commercial educational software used by students | 23 | 82% | 84 | 95% | 52 | 81% | 159 | 88% |
| 3. Teacher developed software demonstrated by teacher | 18 | 72% | 48 | 55% | 35 | 55% | 101 | 56% |
| 4. Teacher developed software used by students | 16 | 64% | 64 | 73% | 40 | 63% | 120 | 67% |
| 5. Student programming | 14 | 50% | 43 | 49% | 23 | 36% | 80 | 44% |
| 6. Bookkeeping/Admin./Grades used by school office | 13 | 46% | 29 | 33% | 19 | 30% | 61 | 34% |
| 7. Bookkeeping/Admin./Grades used by teachers | 13 | 46% | 33 | 38% | 20 | 31% | 68 | 37% |
| Average No. of Terminals | .1786 | | .0795 | | .0156 | | .0722 | |
| Average No. of Microcomputers | 5.0357 | | 4.4773 | | 3.2344 | | 4.122 | |

that they themselves were using computers as much as they would like. Of the teachers, 450 (90%) would like to use computers more in the classroom. The main factor holding teachers back was lack of equipment (57%), closely followed by lack of computer knowledge (43%) and lack of good software (41%). Those who answered "other" to this question almost always listed "lack of time".

Of the teachers replying, 33% demonstrated commercial software in their own classrooms and 37% had students using commercial software. (See Table 2.)

**Table 2. Teacher Computer Usage**

| Usage | Number | % |
|---|---|---|
| 1. Commercial software demonstrated by teacher | 191 | 34% |
| 2. Commercial educational software used by students | 215 | 39% |
| 3. Teacher developed software demonstrated by teacher | 97 | 18% |
| 4. Teacher developed software used by students | 108 | 19% |
| 5. Student programming | 81 | 15% |
| 6. Bookkeeping/Admin./Grades used by school office | 16 | 3% |
| 7. Bookkeeping/Admin./Grades used by teacher | 45 | 8% |
| Average No. of Terminals per classroom | 0.028 | |
| Average No. of Microcomputers | 0.822 | |

**Computer Skills**

The main focus of our survey was to determine which skills were perceived as useful by inservice teachers and also which skills teachers presently have. The results are summarized in Table 3.

**Table 3. Computer Skills**

| Skill | Average Rating of Skill (1-3)* | % Who Have Skill | No. of Replies |
|---|---|---|---|
| Computer Operation | | | |
| 1. Setting up computer equipment | 2.588 | 66% | 523 |
| 2. Inserting disks, tapes, modules | 2.828 | 86% | 519 |
| 3. Loading and running programs | 2.849 | 83% | 524 |
| 4. Stopping or breaking during a program | 2.698 | 71% | 513 |
| 5. The use of all keys on the keyboard | 2.648 | 65% | 527 |
| Hardware | | | |
| 6. Understanding the function of the following: input equipment, memory unit, control unit, etc. | 2.264 | 54% | 522 |
| 7. Distinguishing between hardware and software | 2.366 | 77% | 516 |
| 8. Having knowledge of the rapid developments in computer hardware since 1940 | 1.671 | 43% | 529 |
| Programming | | | |
| 9. Knowing one programming language | 2.514 | 60% | 511 |
| 10. Knowing more than one programming language | 1.954 | 18% | 502 |
| 11. Writing a program to do a single task (i.e., keep track of grades) | 2.388 | 38% | 525 |
| 12. Debugging a program | 2.206 | 29% | 490 |
| 13. Modifying a program | 2.356 | 29% | 514 |
| 14. Developing educational software | 2.138 | 22% | 513 |
| Data Processing/Software | | | |
| 15. Understanding that a computer communicates in binary code | 1.752 | 43% | 482 |
| 16. Recognizing that a computer stores both data and programs | 2.113 | 54% | 504 |
| 17. Recognizing that data processing may involve sorting/updating/ summarizing | 2.014 | 34% | 479 |
| 18. Understanding the function of a computer | 1.842 | 15% | 432 |

*NOTE: 1=Unnecessary, 2=Useful, 3=Valuable

| Skill | Average Rating of Skill (1-3)* | % Who Have Skill | No. of Replies |
|---|---|---|---|
| **Applications** | | | |
| 19. Knowing some of the uses of computers in everyday life in such areas as medicine, law, business, weather, etc. | 2.140 | 48% | 525 |
| 20. Recognizing the advantages of computer use — speed, accuracy, and repetition | 2.304 | 56% | 529 |
| 21. Recognizing some of the problems with computer use — cost, availability of software, storage capacity, etc. | 2.269 | 56% | 523 |
| **Social Impact** | | | |
| 22. Knowing some of the jobs available associated with computers (i.e., computer programmer, systems analyst) | 2.074 | 42% | 510 |
| 23. Recognizing computers have been used to commit crimes | 1.18 | 46% | 512 |
| 24. Understanding some of the issues involved with computer security, passwords, access to information | 1.920 | 34% | 515 |
| **Consumerism** | | | |
| 25. Knowing how to evaluate hardware (computer equipment) | 2.465 | 27% | 529 |
| 26. Knowing how to evaluate software (computer programs) | 2.691 | 42% | 531 |
| 27. Knowing good sources of acquiring hardware | 2.462 | 27% | 523 |
| 28. Knowing good sources of good software | 2.673 | 31% | 527 |

The skill which was judged most useful by teachers was being able to load and run programs, a skill which 83% of the teachers said they possessed. The other most highly rated skills were being able to insert disks, knowing good sources of and evaluation techniques for software, being able to stop a program run, setting up equipment and knowing the use of all keys on the keyboard.

The least useful skills were judged to be knowing the developments in computer hardware since 1940, knowing more than one programming language, understanding that a computer communicates in binary code, understanding the function of a compiler, recognizing computers have been used to commit crimes and understanding the issues involved with computer security.

The skills which were judged useful were largely those which teachers possessed in greater degree. The exceptions were those skills centering around consumerism. Knowing good sources of software (2.67) was a skill possessed by only 30% of the respondents and knowing evaluation techniques for software (2.69) was a skill possessed by only 42%.

It was interesting that while 60% reported knowing one programming language (55% of the total sample knew BASIC), only 37% felt themselves capable of writing a simple program to keep track of grades. This result seems to tie in with the fact that 43% feel that they are held back by a lack of computer knowledge despite the 83% who report having received some kind of computer training (see Table 4).

**Table 4. Computer Training**

| | Number of Responses | Percent |
|---|---|---|
| Teachers indicating they've had some computer training | 458 | 83% |
| Types | | |
| 1. College courses | 212 | 38% |
| 2. Inservice courses | 320 | 58% |
| 3. Private (YMCA, computer stores, etc.) | 91 | 16% |

The overwhelming majority of teachers (83%) had some computer training. Teachers had many comments to make on their training or what training they would like to have. Opinion was divided on whether teachers needed to be able to program a computer themselves.

"My primary interest in taking a computer course at this time would be to learn how to use computers in the classroom and in the context of the curriculum. Things like classroom management techniques (what works, sharing the equipment), teaching kids how to use the computer, examples of programs, etc. I guess I don't really enjoy programming."

"Prospective elementary education teachers should have some training in an appropriate language to use with elementary education students--e.g., LOGO or BASIC."

Many teachers did not seem to be happy with current computer training offerings.

"The classes which I've attended covered too much in too short a time. There's not enough reinforcement or follow-up."

"I am looking for a computer class/course that would be useful for the elementary teacher. I guess I'm looking for something in basic programming, program usage, computer background, how to use a computer effectively in the classroom, etc."

**Recommended Software**

We asked teachers if there was any commercial software they had used that they would particularly recommend. Listed below is any piece of software or line of software which received four or more recommendations. The Bank Street Writer, the Milliken Math Series and MECC software in general received far more recommendations than any of the others.

Specific Packages

Alien Addition, Arcademic Skill Builders in Math, DLM, Addition, Grades 1-3.

Alligator Mix, Arcademic Skill Builders in Math, Addition & Subtraction, Grades 1-3.

Apple LOGO

*Bank Street Writer, Broderbund, Word Processor, Grades 4-12.

Bumble Games, Learning Co., Plotting Number Pairs, Grades K-5.

Gertrude's Secrets, Learning Co., Shapes & Patterns, Ages 4-9.

Mastertype, Lightning Software, Typing Skills, Grades 4 & up.

Micro-math Magic, Hayden Software, Slow Learners' Math, Grades 5-6.

Milliken Language Arts, Grammar problems, Grades 5-9.

*Milliken Math Series, Milliken Publishing Co., Grades 2-5.

Multiploy, Reston Co., Multiplication, Grades 3-4.

Odell Lake, MECC, Science, Grades 3-8.

Pre-Reading/Counting, Elem. Vol. 7 by MECC K-2 Language Arts, Grades K-2.

Story Machine, Spinnaker, Writing Skills, Grades K-4.

General Software Lines

CESA 6 software
DLM series
Hartley software
*MECC software

Teachers also had many comments to make about current software and what they would like to see. A few of these comments are listed below. Many comments stressed the need for better software.

> "There is a need for software that will fit into the currently used curriculum and not drill programs."

Another common complaint was the expense of software and backup disks.

> "There is need for software companies to offer networking fees so that a single piece of software may be duplicated within a district or school building. For example, LOGO was purchased at $90.00 and a backup disk is available at a reasonable cost. We have seven elementary schools that want to use the program. One district could spend $750 for a single piece of software."

Many teachers stressed the need for a sharing of information and the need to preview materials.

> "I would like to see software programs rated as to their excellent/poor quality -- a toll-free number set up so you could call and get information."

> "Schools should continually -- through the media specialist -- provide opportunities for teachers to preview software."

**Recommended Hardware**

We asked teachers which brand of microcomputer they preferred or would recommend to a parent. The microcomputer with the most recommendations was the Apple (154 recommendations) which was cited for its good graphics, keyboard, disk drive, resolution and for the large variety of software available. (One should note that many teachers in recommending the Apple admitted that it was the only micro that they had used.) The Commodore 64 (39 recommendations) and the TRS 80 (22 recommendations) were both cited for good quality at a lower price than the

Apple. Other recommended micros were the IBM PC (17 recommendations), Atari (7 recommendations), Franklin (7 recommendations) and the Super Pet (2 recommendations).

Many of the respondents pointed out that when choosing a computer one must consider how and for what it will be used. Overall, teachers recommended using disk drives rather than cassette players and tapes. Several also strongly recommended standard keyboards rather than the membrane keyboards for children.

## Conclusions

Overall, the picture of computer use in Wisconsin elementary schools is very encouraging. The suprisingly high response rate (43% of the schools contacted) alone is evidence for the great interest of Wisconsin teachers in the role of computers in the classroom. Teachers would certainly like to be using computers more and are held back by lack of computers, lack of good software, and lack of computer skills.

Inservice teachers see the most useful skills for them in what could be called the operational and consumer categories. The valuable skills which teachers most feel themselves to be lacking center around finding and evaluating commercial software. Clearly teacher-developed software would be one solution to this problem. The fact that the majority of teachers know one programming language does not seem to indicate that teachers will soon be developing their own software given that only 22% feel capable of developing educational software and in fact only 38% feel capable of writing a simple grade calculation program.

The least useful skills were perceived to be the more technical ones (binary code, compiler function, etc.) and also those relating to the social impact of computers (computer crime, security, etc.).

While one might argue whether inservice teachers do indeed need the skills which they perceive to be most useful and do not need those seen as less useful their opinion is clearly very important. In the short term, therefore, inservice teachers

would seem to get the most benefit from training focusing on securing, evaluating, and using commercial software. The implications for preservice teachers seem to be that time should be spent on using micros and previewing various pieces of software.

# THE PLAN FOR THE ILLINOIS INVENTORY OF EDUCATIONAL PROGRESS (IIEP) TESTS IN MATHEMATICAL PROBLEM SOLVING

Mervin M. Brennan
Wendell A. Meeks
Illinois State Board of Education

Let us begin by describing the big picture within which the Illinois Inventory of Educational Progress (IIEP) operates and tell you something about the IIEP.

Three contexts stand out for education: the educational, political, and legal. The educational priority is the challenge to develop all students to their full potential. The political focus is the challenge and accountability of the compelling state interest to have an educated citizenry. The legal perspective is the pressure to ensure accountability by establishing minimum requirements. Schools focus on the development of student potential, the State Board of Education emphasizes "compelling state interest," and the Legislature is concerned primarily with accountability for minimum requirements.

The IIEP is the testing program of the Illinois State Board of Education. It attempts to measure the achievement of fourth, eighth, and eleventh grade public school students in Illinois for accountability and challenge. The three goals of the IIEP are (1) to make available relevant, reliable and valid data on the educational achievement of Illinois students, (2) to chart trends in these data; and (3) to conduct and disseminate related research.

The focus and goals of the IIEP mathematics tests have grown since its beginning in 1976. From 1976 to 1981 the tests focused on algebraic and numerical relationships. The foci for the 1980's are narrower: Mathematical Measurement (1982), Geometry (1984), Mathematical Problem Solving (1986), Probability and Statistics (1988), and Technology (1990).

The 1976 goals for the IIEP were simply reports of item results. Subsequently,

other goals were added: trend analysis, psychological and sociological correlates, and curricular data (1978); curricular strengths and weaknesses, factor analysis, and professional judgments (1979-80); hypothesis testing and analysis of other test data (1982); analysis of teaching practices (1984). The hope is for more extensive research in 1986, specifically collaboration of the Illinois State Board of Education, universities and school experimental and case study research on mathematical problem solving in conjunction with the 1986 IIEP.

Intermediate range goals for the IIEP are aimed at 1993. The hope is that we will then have sound tests in the areas of mathematics mentioned above; a first overall snapshot mathematics achievement in those areas; trends for each area over varying years; knowledge of what mathematics is and is not taught; comparative effectiveness of many teaching, environmental, and program variables; and promising hypotheses for future research. The aim is that meaningful conclusions and recommendations will result, that the State Board of Education will understand and use the results to make and implement effective policies, that the Legislature will understand and act upon the results in the best interest of education, especially in terms of budget, and that schools will use the results to enhance student learning.

Turning now to the 1986 IIEP tests in Mathematical Problem Solving, let us state the goals and describe the structure we are operating under. Then we will move to the history and present status of development.

Although the goals for 1986 are still being formulated, at present they are as follows: (1) to gain a picture of student's thinking ability, use of strategies, and ability to arrive at correct solutions when presented with mathematical problems, (2) to learn the extent to which various problem solving strategies are taught and not taught, and (3) to learn the degree to which different methodologies and/or programs develop problem solving ability.

**History.** We've been thinking about the 1986 test since 1982. In the spring

of 1983, we asked a number of people to recommend mathematical educators for a committee. The committee would develop the theory, plans, research and tests. Between phone calls, meetings, and one thing leading to another, we decided on two committees rather than one, with two people having joint membership.

Drs. Kenneth Retzer and John Dossey of Illinois State University are coordinating the efforts of a theoretical committee and a test construction committee. Drs. Randy Charles and Phares O'Daffer of Illinois State University and Dr. Frank Lester of Indiana University have developed the model. Ken Retzer and John Dossey, along with Richard Rukin (Evanston Township High School, Evanston), Cathy Cook (Margaret Meade Junior High School, Elk Grove Village), and Sharon Fresen (Henking Elementary School, Glenview) are developing the tests. The authors represent the Illinois State Board of Education.

The theory, research design, and test development have been in dynamic interaction from 1983 until now and will probably continue that way until the last minute. The theoretical committee worked individually and together, shared their thoughts and drafts with the authors, educated us and listened to our critique. While the theory was being developed, the test development committee was scouring the country for test items. When we had collected over a thousand items we met for a long day in Normal. John Dossey and Ken Retzer oriented the rest of us to the assessment model being developed, and then everyone selected items from the collected pool. After selecting and editing items, we emerged with a final item pool for the pilot tests.

The pilot tests were included in the IIEP tests administered in February, 1984. Approximately 70 items were pilot tested at fourth grade (15 different forms), 95 items at eighth grade (20 different forms), and 85 at eleventh grade (15 different forms). Each form was randomly assigned to 6 or 8 schools in the IIEP sample, and the rotated forms were anchored to the 27-45 item geometry tests and 40-49 arithmetic/algebra tests common to all students.

The items pilot tested thus far have all related to Part 2 of "An Assessment

Model for Problem Solving" by R. Charles, F. Lester, and P. O'Daffer, March, 1984.

This fall the test development committee will develop pilot tests relating to Part I of the model and those items will be pilot tested within the 1985 IIEP using rotated forms randomly assigned to the IIEP sample schools and anchored to a common set of highly stable IIEP mathematical test items.

Subsequent to statistical analysis and identification of items which meet the mathematical and statistical criteria established for inclusion in the IIEP, the research design and test development will be completed by the two IIEP Mathematical problem solving committees.

**The Model.** The Charles, Lester, O'Daffer assessment model has two main parts, each part testing three problem types, seven thinking processes, and nine solution strategies. Publication of the model is in preparation. Descriptions of parts 1 and 2 of the model are given here with a sample test item as illustration and contrast.

Part one of the model tests the ability to perform the thinking processes involved in solving a problem, in contrast to part two which tests the ability to identify the correct answer to the problem.

The following is an item testing part 1:

*Which statement is another way of asking what you are trying to find out in this problem?*

*Problem.* *Jack and Jill collect old buckets. Jill has 3 more buckets than Jack. Together they have 21 buckets. How many buckets has Jack collected?*

*A. *Altogether, how many buckets does Jack have?*

*B. How many fewer buckets has Jack collected?*

*C. How many more buckets has Jill collected than Jack?*

*D. How many more buckets does Jack need to collect to have the same number as Jill?*

The following is an item testing part 2:

*192. Each of five children (Joe, Sam, Sue, Jim and Pam) chooses his favorite color. Joe and Sam do not choose the same color; Sam and Sue do not choose the same color; Sue and*

*Jim do not choose the same color; also Jim and Pam do not choose the same color. What is the smallest number of different colors that could have been chosen?*

*A. 2*

*B. 3*

*C. 4*

*D. 5*

*E. The smallest number is not determinable.*

**The Research.** The research is still in the planning phase. There will hopefully be three major parts.

**Part 1 -** Test and Survey Data

A. An extensive test (perhaps with rotated forms) of Parts 1 and 2 of the model

B. Student questionnaires

C. Teacher (and perhaps principal) questionnaires

**Part 2 -** Experimental Studies

These could involve treatment and control group studies of problem solving teaching strategies, computer programming courses and their influence on problem solving ability, geometry programs, measurement programs, etc. This part is in the brainstorming phase.

**Part 3 -** Case Studies

These would involve onsite studies of schools that appear to be unusually effective or perhaps exceptionally ineffective.

Much of the schema we have described is in early stages of planning and development. The research plans are the least well developed and will be a major planning emphasis in the coming year. We are serious about trying to accomplish all we have described. It remains to be seen how much of it we can accomplish.

# THE ROLE OF MICROCOMPUTERS IN THE ELEMENTARY PRESERVICE PROGRAM

Hal Anderson, Discussion Leader
Eastern Illinois University

Nancy Taitt, Recorder
Eastern Illinois University

The current role of microcomputers in the elementary preservice programs is varied. A survey of the group participants revealed that some schools (Eastern Illinois University, Northern Illinois University, St. Mary's at Notre Dame) offer a microcomputer course designed solely for education majors. In the case of St. Mary's the course is required while at Eastern and Northern it is an elective. These courses cover a range of topics including BASIC programming, CAI, software evaluation, and LOGO. The main objective of these courses seems to be that of helping prospective teachers overcome the anxiety of using microcomputers.

Some schools (Eastern Illinois University, University of Northern Iowa) offer a generic beginning BASIC programming course for all disciplines. The purpose of such a course is to avoid the problem of duplication of efforts by various departments. Separate, more specialized courses can then be offered by the separate departments. This raised the question as to what various departments were doing with this option to offer specialized microcomputer courses. The concensus was that very little is being done currently in most non-mathematics subject areas to integrate the microcomputer into the curriculum.

LOGO and Pascal programming are being taught in some institutions as both computer languages and as means of enhancing students' problem solving abilities. Courses with titles of "Problem Solving with LOGO" and "Pascal and Problem Solving" are being offered for education majors, both elementary and secondary.

Some schools were attempting to integrate the microcomputer into the elementary

school mathematics methods classes (Purdue University North Central, Concordia College). The microcomputer is utilized to teach some of the topics covered in the methods courses. They teach enough BASIC programming in the courses to allow their students to work with the topics. This raised the question of how you add the microcomputer to the methods courses given their already overcrowded curriculums. Some schools used the microcomputer to teach such subjects as probability, coordinate geometry, and problem solving.

Given the variety of methods by which the microcomputer is being integrated into the elementary curriculum, the question was asked "What seems to be the best way to integrate the microcomputer—CAI, programming, or what?" There were several opinions put forth from the group. Some people believed that preparing preservice elementary teachers to teach programming is a waste of time, stating that "Teaching programming to elementary students is a dead end!" and "No problem solving is learned through programming!". Other participants disagreed, stating they believed that learning to program increased students' creativity, citing some of the work by Papert with LOGO. Most participants, however, seemed to believe that learning to program with LOGO is something that most elementary students would benefit from. All those present agreed that major efforts must be made to integrate the microcomputer into the elementary school mathematics methods classes as a tool of instruction. As educators we need to use the microcomputer to the fullest of our potential. While some elementary school teachers may have the time to teach programming in their daily routines, at the present most do not. Thus, in most classrooms where there is a microcomputer available, teachers are going to be using it as a teaching aid. The most effective way of assuring that it is used properly in the elementary school classroom is to use it properly in our own classrooms. This effort is hampered by the lack of good quality software. To address this issue, educators are going to have to do several things: (a) demand that software companies

produce better quality software, (b) seek out and work with fellow staff members and students who have an interest in microcomputer programming and develop needed software, and (c) develop a communication network to keep each other informed when an exceptionally good piece of software is found or developed. Only by working together can we really effectively integrate the microcomputer into the elementary preservice curriculum.

## MATHEMATICAL CONTENT FOR THE ELEMENTARY TEACHERS

Edna F. Bazik, Discussion Leader
Illinois State University

Larry Sowder, Recorder
Northern Illinois University

Dr. Bazik summarized the 23 responses to her polling of mathematics educators in Illinois, Indiana, and Iowa. The results gave information about the number of hours in the required content courses for elementary teachers, the topics covered, and texts used. The number of content hours required varies considerably, ranging from a 3-hour course only strongly recommended to 10 quarter hours and 9 semester hours (see Table 1).

**Table 1**

**Number of Hours in Required Content Courses in Mathematics for Elementary Teachers**

| Number of Hours | Number of Schools |
|---|---|
| (Semester Hrs.) | |
| 3 | 3 (inc. one where only strongly advised) |
| 4 | 2 |
| 6 | 6 |
| 8 | 1 |
| 9 | 5 |
| (Quarter Hrs.) | |
| 4 | 1 |
| 8 | 3 |
| 10 | 1 |

With this variety, it is no surprise that the tabulation gave a long, varied list of topics (Table 2), with over 20 books being used across respondents.

**Table 2**

**Topics Cited as Included in Required Content Courses for Elementary Teachers**

| | | |
|---|---|---|
| sets | relations | functions |
| numeration | history of numeration | number systems |
| whole numbers | prime numbers | modular systems |
| integers | rational numbers | irrational numbers |
| real numbers | complex numbers | properties of a number system |
| number theory | exponents | fractions |
| decimals | algorithms | arithmetic |
| geometry | coordinate geometry | measurement |
| logic | problem solving | probability |
| statistics | flow charts | BASIC |
| LOGO | calculator usage | computer usage |
| equations | inequalities | graphing |
| quadratics | similarity | systems of equations |
| linear measure | angular measure | systems of inequalities |
| area | volume | polyhedra |
| constructions | congruence | reasoning |
| transformations | variation | ratio |
| proportion | percent | metric system |
| combinatorics | algebraic system | introductory trigonometry |

Participants raised several questions about the extent of the coverage and whether emphases had changed:

- Is computer work a part of the required course? Yes, for about one-third of the participants in the session. Exposure may be minimal--e.g., one week, or introduction to software.

- In the view of the participants, geometry and measurement deserve, and get, much attention in the required courses, including efforts to change some students' attitudes toward geometry so they will be less likely to skip geometry in their teaching. An activity orientation, work in three dimensions, transformations, constructions (including MIRAs), and measurement of perimeter, area, and volume came up as topics covered by participants. Formal proof was <u>not</u> emphasized.

- The participants seemed to share a positive feeling toward continuing to work with metric units, citing their based-on-ten nature and the ease of estimation in metrics, as contrasted with English units.

- The concern was expressed that a too abstract course could result in an even <u>greater</u> mathematics anxiety among students.

- Nonstandard algorithms, algorithms in different bases, or algorithms used in other countries were cited as a means of changing students' narrow views of mathematics.

- Are some old standbys like ancient numeration systems and numeration in different bases getting less attention? The vocal participants said no, seeing different bases as a means of strengthening place-value understanding and appreciation.

- Sets, too, seem to be surviving, with the extent of the work perhaps being somewhat curtailed.

- Little time is spent on algebra (except in separate algebra courses).

- Roughly 40% of the participants use a pretest for admission to the required coursework (or the program in which the required coursework appears). In many cases, the test is only arithmetic proficiency. In one case, students who do not pass the pretest are required to take an algebra course.

## TECHNIQUES IN TEACHING DIAGNOSIS IN MATHEMATICS METHODS

Judy Sowder, Discussion Leader
Northern Illinois University

Ruth Champagne, Recorder
Concordia College
River Forest, Illinois

The discussion leader suggested that the main question to be addressed during the session is: "How can we teach students in our methods courses to be better at diagnosis?". She then suggested two alternative approaches:

1. The discussion could focus on sharing what is done by different instructors in methods courses to teach diagnosis.
2. The discussion could focus on the implications of Robbie Case's model for developing instruction. The discussion leader shared some features of the Case model saying that she hoped to use the model to study how children develop estimation skills and concepts. According to the Case model reported in the article "A Developmentally Based Theory and Technology of Instruction" (Review of Educational Research, Summer 1978, vol. 48, No. 3, 439-63), young children's thinking has two characteristics: (1) Children tend to use reasonable but oversimplified strategies for coping with school tasks; (2) Students are not capable of coping with informational demands. In order to respond to these characteristics, Case's model suggests three things: (1) A step-by-step description of the strategy to be taught should be accompanied by a description of strategies that children tend to use spontaneously; (2) Instruction should be designed to show the limitations of children's spontaneous strategies as well as the need for applying the strategy to be tauaght; (3) In selecting models and designing instructional strategies, working memory requirements must be reduced to a minimum.

Session participants decided to focus the discussion on the first approach suggested

by the discussion leader and began to share information about what is done in methods classes to teach diagnosis in mathematics. The following comments were made by participants.

- Methods students can be given problems similar to those presented by Ashlock in his book dealing with error patterns in computation. Methods students can then be asked to diagnose errors and suggest strategies for remediation. One participant commented that he developed a practice activity whereby students generated their own sets of problems with error patterns and gave these to other methods students for diagnosis. The participant felt that this method had worked well, that students became more familiar with error patterns and children's thinking when asked to think in these modes, and that they did make a conscious effort to look for error patterns when working with students in a classroom.
- Methods students can be asked to classify student errors according to the model reported in an NCTM Yearbook article by labeling errors as systematic, random, or careless. Using the 3 out of 5 rule, methods students are asked to administer 5 items that test a single skill. If 1 or 2 errors are made, the errors are regarded as careless errors. If 3 or more errors are made, students are taught to look for an error pattern. If an error pattern is detected, the errors are categorized as systematic. If no error pattern is detected. the errors would be classified as random errors. The participant who contributed information about having used this model successfully with methods students indicated that methods students had far more difficulty developing remediation strategies than diagnosing errors.
- Methods students can learn diagnosis by having an infused model of special education running through their methods courses rather than taking a separate three-hour course in special education. Using this model, students in math methods courses can develop an IEP for a student by completing a four-part

assignment in conjunction with errors that are made by elementary school children: (1) Diagnose the error; (2) Write a short-term objective for the student; (3) Write five remedial strategies to be used by the student; (4) Determine how mastery of the objective will be judged.

- Methods students can be given an assignment to administer a test to a few (4 or so) elementary school children. Tests can be collected by the methods instructor, shuffled, and redistributed to methods students for analysis of error patterns. Methods students soon realize that a few papers would not be sufficient to detect an error pattern, but that error patterns can be more easily detected with 10 or more students' papers. Methods students also see that elementary school students must show their work in order for errors to be detected. This approach to the topic of diagnosis in a methods course provides a population of elementary school children for diagnosis, but not for actual work with children in remediation.
- Methods students can become familiar with microcomputer programs related to diagnosis in mathematics. Some sample programs mentioned were John Seeley Brown's software program, "Buggy." The philosophy behind this program is that if a student can debug a problem, or do one like one that has been done incorrectly, then the student understands the thinking required for that type of problem. Another type of program that methods students can become familiar with is the concept of adaptive testing developed by Kumi Tatsowoki (Ed Psych Department/ University of Illinois--Champaign campus) whereby a child's test will change depending on the answer given by the child. The error a child makes is "diagnosed" by the software program and a message is typed out about the child's error for the teacher to see. An adaptive testing program for decimals is now being completed and other programs are being planned.

- Methods students can be required to tutor students in elementary schools as a component in the methods course. Having a lab school makes it easier to implement this component of a methods course. A source of activities and materials that has been helpful to methods students who serve as tutors is Richard Copeland's book on math activities for children.

The discussion closed with some more general observations:

— Methods texts don't deal much with the topic of diagnosis and this may be partly responsible for the fact that diagnosis is not receiving as much emphasis as it should in methods courses.

— The time constraints in methods courses lead to a de-emphasis of the diagnosis topic (participants noted a range of 6-11 semester hours of math and math methods required in the programs at their schools).

— Many methods students have weak skills and competencies and high math anxiety.

# THE ROLE OF MICROCOMPUTERS IN THE SECONDARY PRESERVICE PROGRAMS

Leona Mirza, Discussion Leader
North Park College

Patrick Coulton, Recorder
Eastern Illinois University

The discussion leader began with this outline:

I. Encourage mathematics students to have at least one course in computer science, preferably with a mathematical bent.

II. Devote a portion of the methods course to ways in which the computer can be integrated into mathematics courses. These should be creative and discovery uses. They should include experience with:

- A. Types of software
  1. drill and practice
  2. instructional programs
  3. simulations
- B. Evaluation of software
- C. Problem solving
- D. Bibliographic searches
- E. An alternative for those who fail
- F. Practical application of mathematics

It was also mentioned that an intelligent choice of software can reduce or eliminate the gender gap which results from the lack of desire to use computers among some women.

Discussion follows:

It was pointed out that mathematics teachers are most often the teachers chosen at the high school level to begin computer science programs. This in turn raises the question: should the curriculum for teachers include a special course

in applications of computers in teaching high school mathematics. The inherent problem results from the fact that there is little room in the curriculum for additional courses. All of those present represented schools that require a course in computer programming for mathematics teachers. It was felt that this course was very important before the methods course, since there is not time during that course to teach computer science, but some time should be devoted to applications. It was mentioned that many states may go to a computer science requirement. Indiana was given as a specific example.

There was a feeling among the group that teaching computer literacy was not necessarily the best use of a mathematics teacher. Rather, the computer should be a tool at the disposal of the mathematics teacher. In particular, the computer is useful in the teaching of procedural thinking. The computer language LOGO was mentioned as a specific example for use in procedural thinking.

Those present felt that there was some need for certification in computer science. Several states, including Illinois, have created that option, but few universities have such programs. Apparently, there are states which are certifying computer science teachers, but there is not yet a national trend.

It was mentioned that Kohl Education Center, 415 Greenbay Road, Wilmette, Illinois has computer software available for teachers to preview. The group also discussed the need among university faculty for education in the field of computer science. It was pointed out that Barry University in Miami, Florida has 30 courses in computer education alone.

There was a general feeling that teachers may not be getting what they need to use computers in the classroom. In particular, systems management, software use, and applications were mentioned as important skills for the secondary teacher.

Finally, it was conjectured that many of the problems of educating mathematics majors to teach computer science may be gone in four years when the present high school students reach college.

## RETRAINING TEACHERS WHO ARE NOT CERTIFIED IN MATHEMATICS

Donald Whittaker, Discussion Leader
Ball State University

Russel Day, Recorder
Illinois Central College

The following handouts formed the basis of opening the discussion on retraining teachers:

The Mathematics Teacher Shortage and Retraining Programs
(NCTM Position Summary, April, 1983)

"GAO Criticizes Attempts to Upgrade Skills of Math, Science Teachers"
Phi Delta Kappan, May, 1984, p. 653.

Certification of Teachers of Mathematics
(ERIC Mathematics Education Fact Sheet Number 1, 1983)

State of Indiana Commission on Teacher Training and Licensing

The six major points of the NCTM position paper were quickly reviewed and agreed upon as desirable:

1. Fully qualified mathematics teachers at all levels.
2. Mathematics teachers should work to remove deficiencies.
3. Mathematics teachers should work to upgrade their knowledge of mathematics and the skills for communicating it to students.
4. Different levels of government, school districts, and institutions of higher learning should cooperate in addressing the problem of the shortage of qualified teachers of mathematics by establishing programs for training and retraining with appropriate and sufficient financial support.
5. School districts experiencing difficulty in attracting and retaining qualified mathematics teachers should explore innovative strategies.
6. Public relations are needed to bring the seriousness of the mathematics teacher shortage to parents, teachers, and policy makers at all levels and these persons should be actively involved in formulating solutions to this problem.

A number of questions concerning references to "study" and "research" in the GAO article reprint. No one in the discussion group knew what "study" or "research"

was involved. The authors maintained that the GAO could not determine whether national shortages of mathematics and science teachers exist or even whether the quality of teaching has declined. GAO recommends retraining programs draw in uncertified teachers and experts in industry to fill the gap.

Indiana has a General Mathematics Endorsement (15 semester hours). It was enacted without one voice speaking in favor of it at a Commission on Teacher Training and Licensing hearing, though many testified against the endorsement.

The holder of the endorsement in general mathematics is eligible to teach in grades 5-12 all arithmetic courses and only those in general mathematics which are not used as prerequisites to a standard secondary school mathematics sequence of algebra, geometry, etc.

The candidate is expected to have completed two (2) years of high school algebra and one (1) year of high school geometry. Coursework shall include:

| | |
|---|---|
| The real number system and its theory | 3 sem hrs |
| Finite mathematics | 3 " " |
| Statistics and probability | 2 " " |
| Foundations of mathematics | 2 " " |
| Problem solving | 2 " " |
| Methods of teaching general mathematics | 2 " " |
| Computer science | 1 " " |

There is a renewal clause in this act and a general clause which includes "In no case would the mere realignment of existing courses be seen as adequate in meeting the needs outlined above for the prospective teachers."

Members of the discussion group from Indiana stated it will probably not be implemented as the major schools do not intend to create the necessary special courses.

Other members of the discussion group including representatives from schools

in Missouri, Wisconsin, Tennessee, and Illinois spoke of efforts in retraining teachers in their states. One important point was evident throughout: "retraining" does not have the same meaning in every state. There is planning of structured programs, partially structured programs, and no structure at all where retraining of teachers of mathematics is considered. It was clear that each area and institution has distinct and separate problems with retraining programs.

Some comments and questions were voiced concerning the finances of programs. Where should the money be raised, to whom should it be paid (individual versus school), how can we be sure it results in quality teachers? No definitive solutions were offered.

# RESEARCH ON HOW STUDENTS ACQUIRE AND USE PEDAGOGICAL KNOWLEDGE

Fred Flener, Leader
Northeastern Illinois University

Janet Hartman, Recorder
University of Evansville

The focus of this session was interpreted to be how mathematics methods students acquire and use pedagogical knowledge. Acknowledging that little research exists on this particular topic, the discussion turned to how students acquire the qualities and skills which effective teachers possess. The discussion centered on the following topics:

1. How to increase the clarity of instruction by methods students
2. How to educate students in the use of evaluative techniques
3. How to educate students in the use of alternative strategies
4. How to give students insights into providing contexts for mathematical learning
5. How to help methods students become more task oriented
6. How to impart enthusiasm and strategies for classroom management to students

The group agreed that teaching students how to be clear in their presentation of subject matter was difficult. Behaviors in this category are highly individualized.

An introduction of the topic of evaluation led to a discussion of some research which indicates that grading of homework has little influence on student achievement but feedback from homework is important. Some concern over the use of homework by teachers with student teachers was expressed. The first assignment that students are often given in student teaching is to grade homework papers. Participants felt that students were not exposed to effective methods of utilizing homework. Some concern for external influences on teacher behavior patterns regarding homework was expressed along with the idea that student expectations often lead teachers

to adopt counter-productive procedures with regard to homework. As an alternative to homework, because of its seeming lack of influence, it was suggested quizzes be given.

In discussing time on task as it relates to presentation and work on mathematics, it was suggested that students can acquire skills by observing teachers in good field experience placements.

Preservice teachers sometimes spend time in preparing for specific areas in teaching. It seems that this learning is a series of isolated incidents and that more effort needs to be expended in teaching preservice teachers how to integrate activities and processes in a classroom environment. A cookbook approach was suggested as an alternative since there is some evidence that this seems to be effective. Preservice teachers are often unfamiliar with contexts in which to present mathematics. Alternative approaches utilizing a context base are used by Zoltan Dienes and Zalman Usiskin. It was mentioned that Usiskin's approach to teaching algebra has not been well received. Many students are unable to create contexts because they are struggling to gain mastery of the mathematics concepts and adequate methods of presenting them. Perhaps methods classes should include more activities to help students develop a collection of contexts in which some mathematical concepts are used.

Methods courses could draw on the expertise of the instructor in demonstrating several different teaching strategies for the same topic. Methods instructors could also demonstrate some other skills such as wait time, questioning, introduction, closure and presentation of material in appropriate logical steps.

Peer teaching was discussed. Mixed feelings were expressed. While most group members felt peer teaching valuable in teaching technical skills, some felt that it was not adequate for presenting context. Teaching peers does not provide the student teacher with as much insight about how children learn the subject matter as does teaching children.

The inclusion of methods for teaching basic mathematics in a secondary methods

class was discussed. Many first year teachers are assigned to general math classes without appropriate skills to teach general math.

The last topics of discussion were classroom management and generation of enthusiasm. Like teaching styles, management styles are highly individualized and experiential in nature. To transmit enthusiasm it was suggested that the methods instructor should be a good role model and guide students in directions which keep them intellectually stimulated.

The consensus was that our group had only begun to deal with methods of giving students a broad pedagogical base from which to work. An item of high priority in training students to teach which arose several times in our discussion was that of providing exemplary role models. Since students do model those who teach them, it seems critical to provide experiences with teachers who themselves use good pedagogical strategies.

## INSERVICE EDUCATION

Loretta Meeks, Discussion Leader
Sangamon State University

Charles Pettypool, Recorder
Eastern Illinois University

The presider raised the questions: "Should we seek external funding?" "Should we pay teachers to come?"

There seemed to be a concensus that there should be inservice education, whether or not there is external funding, because it is needed. The presider reported also that there seems to be greater satisfaction about the progress of inservice education (on the part of the college teacher and the public school teachers involved) when the public school teachers help in deciding what is needed. The teachers also seem to prefer inservice education on their "own ground."

Concerning the question: "Should teachers learn programming of computers or just how to run packages?", there seemed to be some difference of opinion. It appears that teachers want to consider how to evaluate software--"what to look for." It was suggested that evaluation of software be done by exposure to numerous types, raising the question "Does the program do the thing expected of it?"

In a similar way textbook selection (evaluation) can be improved by examining textbooks along with concept development, raising the question: "Does the text teach the concept?"

The presider described a three-semester-hour graduate credit workshop that met four hours a day, June 11 to June 22, in the school of the teachers involved. The teachers had selected a text series using the NCTM "Ten Basic Skills" list. They felt a need for "what to do with manipulatives." The presider taught concept development along with the use of manipulatives, with concept development before practice. The teachers had the workshop session in the morning and then had the use of their school room and materials for making and planning the use of manipulatives

in the afternoon.

Another member of the discussion group reported a one-hour-per-week inservice class held during the school year for one semester. The course on microcomputers was for one semester hour graduate credit. The teachers involved seemed well pleased with the course and seemed to prefer that it be taught during the school year.

The session closed with the presider handing out copies of Proposals for the Provision of Inservice Education and Staff Develoment of Mathematics Teachers in Illinois, Recommendations of the State of Illinois Mathematics Committee.

# MATHEMATICAL CONTENT FOR SECONDARY TEACHERS

## THE CUPM REPORT

Don S. Balka, Discussion Leader
Saint Mary's College
Notre Dame, Indiana 46556

Donna L. Siemro, Recorder
Governors State University
University Park, Illinois 60466

The discussion focused on the report of the Commission on the Undergraduate Program in Mathematics (CUPM) Panel on Teacher Training: Recommendations on the Mathematical Preparation of Teachers (1983). The Level III recommendation (see page 59) that the preparation of all teachers of high school mathematics should minimally include the content of the following 13 courses was the central point of discussion:

- Discrete Mathematics
- Calculus Sequence (3 courses)
- Introduction to Computing
- Mathematics Appreciation
- Linear Algebra
- Probability and Statistics
- Number Theory
- Geometry
- Abstract Algebra
- History of Mathematics
- Mathematical Modeling and Applications

Balka noted that the CUPM course list was "an effort by the mathematical community to interpret NCTM's Guidelines for the Preparation of Teachers of Mathematics." In the future, the National Council for the Accreditation of Teacher Education (NCATE) will use the NCTM Guidelines as the basis for evaluation of secondary school mathematics teacher preparation programs in teacher training institutions.

Throughout the discussion, it was evident that the curricula at the college and universities represented include most of the topics covered in the 13 courses. However, in many cases, topics are covered in courses other than those with the specific titles listed in the Level III recommendation. It was also noted that at small schools with few faculty in a mathematics department, it would be impossible to deliver

all the courses listed. Suggestions were that some courses (e.g., History of Mathematics) could be offered every two years.

With the Level III recommendation assuming that entering college students have completed four years of college preparatory mathematics and have "mastered" a number of topics traditionally taught in College Algebra, the discussion leader asked the group how many of their students are adequately prepared upon entering college for the content of the courses listed. The group agreed that "what one has been taught" and "what one knows" often differ. Exposure to a topic/content does not imply mastery of that content.

Specifically, in algebra, entering students are often weak in understanding and the application/use of: logical propositions, truth tables, permutations, combinations, and proof by mathematical induction. In some cases, these topics may never have been covered in high school courses. Students who need to review algebra topics should complete a College Algebra course before proceeding with the college mathematics curriculum.

It was agreed that in geometry and trigonometry, students often enter college with poor understanding of trigonometry. Specifically, calculus students lack understanding of and skill in using trigonometric identities and equations, and the trigonometric form of complex numbers using DeMoivre's Theorem.

Participants suggested that in the teacher education program, a review of topics not covered in the course sequence might be included as topics to be taught as mini-lessons in the mathematics methods course or to be presented by students in a junior/senior level seminar course (e.g., present DeMoivre's Theorem as a seminar topic).

The CUPM list includes a course in Mathematics Appreciation. Concern was expressed that there is no agreed-upon content for suh a course and that it could be interpreted as a "consumer mathematics" course. A participant noted that a

student would truly appreciate mathematics only by doing a mathematical investigation, an activity that is generally beyond the scope of a teacher preparation curriculum.

A suggestion was made that a course in Number Theory would be a good course to introduce students to the "meaning" of mathematics. This course could focus on proofs and patterns in mathematics and provide a philosophical base for advanced courses in the curriculum.

Curricula at most schools represented require students to complete a geometry course. In many cases this course is too high-powered for what high school teachers actually need. It may be more appropriate to teach the course from a more informal approach and emphasize transformational geometry, as suggested in the CUPM course description for geometry. Modern Geometry (Smart) was recommended as an appropriate text for such a course.

Most institutions required a computer course in the teacher preparation program. Participants noted, however, that all the described content for the CUPM recommended Introduction to Computing course would be very difficult to teach in a normal three credit hour semester course and that additional courses would be necessary.

Balka conducted a survey of participants regarding the CUPM recommended courses that are required in their particular secondary teacher preparation programs. Participants were asked to indicate in what course(s) the content was covered if no course with the specific title was required. The survey results are on the next page. The data reveal that the only specific courses required by the majority of schools represented in the survey are: calculus sequence, geometry, linear algebra, probability and statistics, abstract algebra, and introduction to computing.

**Survey of Teacher Training Institution Courses**

**Course Content for CUPM Recommendations**

Number Responding: 11

| CUPM Recommended Course | Required | Elective | Content Covered In: |
|---|---|---|---|
| Discrete Mathematics | 4 | 1 | Probability & Statistics |
| Calculus Sequence (3 courses) | 11 | | |
| Introduction to Computing | 7 | 2 | BASIC, Computers & Society, Education Course |
| Mathematics Appreciation | 1 | | Gen. Ed. requirement, Required seminar, Tech. Sec. Math, Foundations of Ed. |
| Linear Algebra | 9 | 2 | |
| Probability & Statistics | 8 | 3 | |
| Number Theory | 2 | 5 | |
| Geometry | 10 | | |
| Abstract Algebra | 7 | 3 | |
| History of Mathematics | 1 | 4 | |
| Mathematical Modeling and Applications | 2 | 1 | Linear Algebra, Calculus, Probability, Geometry |

## LEVEL III RECOMMENDATIONS

The preparation of all teachers of high school mathematics should include at least the mathematical content of the following thirteen courses:

Discrete Mathematics
Calculus Sequence (three courses)
Introduction to Computing
Mathematical Appreciation
Linear Algebra
Probability and Statistics
Number Theory
Geometry
Abstract Algebra
History of Mathematics
Mathematical Modeling and Applications

Teachers of calculus should have additional work in analysis including the background for teaching the content of the Advanced Placement calculus course.

It is assumed that students entering a program will have completed four years of college preparatory mathematics, and should in particular have mastered a number of topics which have traditionally been taught as "College Algebra."

Algebra: Logical propositions, truth tables, patterns of inference; permutations, combinations, simple counting problems; the binomial theorem; trigonometric identities and equations; properties of and operations with complex numbers; trigonometric form of complex numbers and DeMoivre's Theorem; exponential and logarithmic equations; proof by mathematical induction; arithmetic and geometric sequences and series; matrices and determinants.

Geometry: Analytical geometry of the plane, transformations (translations and rotations), the conic sections, Law of Sines and Law of Cosines, vectors, polar coordinates.

Functions: Polynomial functions and their graphs, exponential and logarithmic functions and their graphs, circular and inverse circular functions and their graphs.

All mathematics courses should be structured and taught so as to develop and maintain student interest and enthusiasm for mathematics. As prospective teachers the students in these courses must learn to communicate their knowledge of mathematics. Thus the courses should be designed to encourage active student participation. It may, for example, be appropriate to offer one or more of the courses in a seminar format in which students present selected material to the class. A problem seminar or student colloquium series could also provide opportunities for students to sharpen their skills in discovering, and communicating, mathematical concepts.

## DISCRETE MATHEMATICS

Objectives:

1. Develop basic techniques and modes of reasoning of combinatorial problem solving,
2. Describe and analyze the algebraic structures of certain set-relation systems,
3. Illustrate and analyze the wide variety of applications of discrete mathematics.

Topics:

Mathematical Induction: weak induction, strong induction, recursive notation.

Set Theory: notation, basic properties, Venn diagrams, pigeonhole principle, truth tables, propositional calculus.

Relations and Functions: binary relations, order relations, lattices, functions.

Combinatorics: counting arguments, permutations, combinations, principles of inclusion-exclusion.

Graphs: planar graphs, trees, paths and their use in searching, coloring, Eulerian and Hamiltonian graphs and their applications, graph based games.

Boolean Algebra: elementary definitions, examples and properties, principles of duality, lattices, switching circuits.

Difference Equations: recurrence equations, generating functions, Fibonacci numbers and their applications.

In addition, it is suggested that at least one of the following topics be selected and treated with some depth:

Elemetary Probability: basic laws of discrete probability, discrete probability distributions, random number generators, basic ideas of queueing theory.

Algorithms: notation for expressing algorithms, analysis of algorithms.

## MATHEMATICAL MODELING AND APPLICATIONS

Objectives:

1. Familiarity with a variety of applications of each of the major topics of school mathematics;

2. Sensitivity to opportunities to use mathematics in fresh ways to deal with real-world problems;

3. An acquaintance with and understanding of some of the best accounts of the nature of mathematical modeling, and the ability to analyze specific instances of it within the framework provided by those accounts;

4. Knowledge of reasonable standards for good textbook "story problems" and the ability to use those standards to evaluate problems and to create good new ones;

5. Familiarity with existing sources of applications of school mathematics;

6. A capacity for the infectious enjoyment of good applications;

7. Exposure to some mathematical ideas, for example in discrete mathematics, that may not be met in other courses;

8. Acquaintance with the principal mathematical needs of people in some of the trades, professions, and scientific disciplines.

Possible Topics:

Tax incentives to pollution control
Applications of graph theory to archaeology
The measurement of voting power
Population
Linear programming
Traffic lights
Packing and covering

## SURVEY OF TEACHER TRAINING INSTITUTION COURSES
## COURSE CONTENT FOR LEVEL III RECOMMENDATIONS

According to the CUPM Panel on Teacher Training, the preparation of all teachers of high school mathematics should include at least the mathematical content of the following thirteen courses. Check the corresponding blank if such a course is required for secondary teacher preparation. If a course is not required but the content is covered in a different course, indicate the name of the course.

| Course(s) | Required | Content Covered In: |
|---|---|---|
| Discrete Mathematics | _____ | _____ |
| Calculus Sequence (3 courses) | _____ | _____ |
| Introduction to Computing | _____ | _____ |
| Mathematics Appreciation | _____ | _____ |
| Linear Algebra | _____ | _____ |
| Probability and Statistics | _____ | _____ |
| Number Theory | _____ | _____ |
| Geometry | _____ | _____ |
| Abstract Algebra | _____ | _____ |
| History of Mathematics | _____ | _____ |
| Mathematical Modeling and Applications | _____ | _____ |

## RESEARCH ON TEACHING METHODS IN MATHEMATICS

Anne Madsen-Nason, Discussion Leader
Michigan State University

Milton Mitchell, Recorder
University of Wisconsin,
Platteville

The presider related research from the General Mathematics Project conducted at the Institute for Research on Teaching at Michigan State University. It was found that there are two underlying difficulties with general mathematics: (a) Students don't want to take it, and (b) teachers don't want to teach it.

Problem areas for teachers and for students seem to be primarily in the areas of communication, organization and content. An intervention strategy was developed to change constraints on teaching and on learning in the general mathematics classroom.

Initially it was found that:

1. Communication between the teacher and students concerning the content of mathematics was minimal.
2. Students communicated with the teacher to find out what they had to do in order to complete their daily assignments.
3. Teachers communicated with students to give directions on how to work assigned problems and to provide answers to the assigned problems.
4. Teachers used less math-specific language in their general mathematics classes than they did in their algebra classes.
5. The wide range of levels of ability of general mathematics students was troublesome for the teachers in planning for instruction.
6. Large class size prohibited individualizing instruction, yet variation in ability levels reduced the effectiveness of whole-group instruction.
7. Whole-group instruction was limited to minimal explanation of the daily task, assignment of seatwork, and checking student work at the end of the class.
8. Although teachers expected students to work individually during seatwork time, the students formed groups in order to socialize as they worked.
9. The teachers believed general mathematics students needed a daily routine

of many practice problems in basic arithmetic algorithms. This practice formed the core of their instruction.

10. General mathematics students expected their class to be a review of basic arithmetic. Since this was their last mathematics class, they did not expect to learn any new mathematical content.

11. Neither teachers nor students thought the content of general mathematics was interesting or challenging. The content was tolerated and accepted as the work which general mathematics teachers and students had to endure.

The instructional improvement strategies involved (a) increasing the quality and quantity of communication about the mathematical content, (b) facilitating instruction through the social organization of the classroom, and (c) modifying or adding new mathematical content to the general mathematics curriculum.

The quality of communication was improved by (a) changing telling/lecturing to questioning, discussing, controlled practice, and student explanations and (b) by changing single-word answers to error analysis, discussing, questioning, and student explanations.

The classroom organization was changed by grouping students, having group captains and recorders, grading both individual and group work, beginning the period with a 4-5 problem review of previous day's work, and by using overhead projector to focus student attention on the lesson.

Mathematical content was changed by:

1. Focusing on developing linkages to move the student from concrete to abstract by using manipulatives.

2. Focusing on problem solving strategies.

3. Adding new units of content on probability, similarity, statistics, outdoor measurement, problem solving, and gardening.

4. Dropping old units of content on drill and practice of arithmetic algorithms and whole number reviews.

Several important changes occurred during the study, namely:

1. Lesson development increased from 16.9% to 25.1% of classroom time.

2. Checking of work increased from 1.8% to 16.3% of classroom time, primarily because of time spent on teacher and student analysis and discussion of errors.

3. Seatwork decreased from 47.5% to 38.2% of classroom time.

4. Socializing decreased from 13.6% to 0.5% of classroom time.

5. Pretest and posttest results of the Stanford Diagnostic Mathematics Test indicated that the target classes had greater gains than the control classes on computation, applications, and on the total test, in one of the participating schools. The data from the other schools involved in the study is still being analyzed.

6. Student attitudes toward mathematics improved during the study.

The discussion during and following the presentation touched on the following:

1. Did students think of content as "the same old thing" and resist using manipulatives?

2. What was the reaction of the control teacher? Will he change?

3. What does this study infer about inservice programs for teachers?

4. What is the cost of this method of changing teacher behavior?

5. What are the characteristics of general mathematics teachers?

Question 1 was answered in the negative and question 2 in the positive. However, no definitive answers were arrived at for questions 3, 4, and 5.

To obtain more information about the study referred to above, contact:

Anne Madsen-Nason
252 Erickson Hall
Michigan State University
East Lansing, MI 48824

# RUNNING A MATHEMATICS CLINIC AS A METHODS COMPONENT

Frederick L. Brumbaugh, Discussion Leader
Ball State University

Alice I. Robold, Recorder
Ball State University

A graduate course for elementary school teachers, MATH 591 at Ball State University, is usually referred to as "the math clinic." Each graduate student is assigned two children. The first class session provides instructions to the graduate students, then the children meet with their graduate-student teachers each of the 23 or 24 class days thereafter for 45 minutes each day. During the rest of each class period the graduate students learn about diagnosing and teaching mathematics concepts. At their first session, the children are given the KEYMATH diagnostic test. Place value and other concepts are diagnosed as well. Based on profiles from the KEYMATH test, other concepts are diagnosed the next day. Graduate students continue with informal diagnosis throughout the term, listening to children's answers to questions to aid their decisions. Emphasis is placed upon the use of manipulative approaches to concept development. A wide range of concepts must be taught to each child. Geometry and fractions, for example, are likely to be included along with many other topics that are appropriate for a given child.

The undergraduate mathematics methods course for preservice elementary teachers, MATH 391 at Ball State University, also requires work with children. Each student enrolled in MATH 391 indicates a choice of primary, special primary, intermediate or special intermediate levels. A child is then assigned to be tutored for seven 45-minute sessions after an initial get-acquainted session. College instructors and the children's teachers at the Burris Laboratory School work together to make the assignments. Children for whom their teachers feel this would be a desirable

experience may be at any achievement level. The tutoring is not designed for remediation. In the first session, tutors do informal diagnoses of several concepts using mostly manipulative approaches and including several of Richard Copeland's tests, related to Piaget's findings. In each of the remaining six sessions, each tutor must teach three 15-minute learning activities, each on a different mathematics concept. The tutor must teach at least one lesson on each of several assigned topics during the term. Manipulative aids must be used for each concept.

Before the tutor is allowed to teach the lessons, plans are approved by the college instructor. The one-page plan for each 15-minute activity includes the behavioral objective, the readiness for the concept that the tutor has observed, the plan for conducting the activity, significant questions the tutor will ask during the activity, a list of materials needed, and the reference source used for the lesson idea.

Each tutor chooses which hour he or she will meet with the child on Tuesday of each week. Tutor-child pairs are scattered about the auditorium, sitting on the floor during each of four hours. The college instructors of the methods classes supervise the tutoring sessions.

Students attend the methods class three hours per week (about 30 sessions). The tutoring is done outside of class time. Neither students nor instructors receive load credit for the tutoring time. It is indeed a lot of work, but students learn much that they could not otherwise have learned.

# RECRUITING AND MAINTAINING STUDENTS IN TEACHER EDUCATION CURRICULA

Bruce Williamson, Discussion Leader
Wisconsin State University, River Falls

Claire Kruckenberg, Recorder
Eastern Illinois University

The presider opened the session by providing the following outline, then gave an overview and opened the floor for general discussion. A brief summary of the overview and discussion follows the outline. Included is a list of references and resources.

The problem:

Recruiting and maintaining students in teacher education curricula.

Understanding the problem:

a) Two distinct but related features (recruit/maintain).
b) Teacher education in general has had bad (discouraging) press.
c) Part of a larger problem; the sorry state of PR in mathematics in general.
d) Lack of rewards (both salary and working conditions).
3) Other

Devising a plan

a) What is already being done?
   i) federal/state legislation
   ii) programs in progress
b) What is proposed?
c) Ideas from the participants.

Carry Out the Plan

a) Who's going to do it?
b) Will the various "publics" help?
c) What about the future (5-10 years)?

Looking back

a) What have we missed?
b) Can we really make a difference?

Summary:

The problem is real (see references) but seems to be rebounding.

Understanding the Problem

The mathematics teacher shortage could have good effects (i.e., increase salaries) and could have adverse effects (ill prepared teachers, minimally retrained teachers--especially in states with low certification requirements). The Indiana representative of Cooperation for Science and Technology, a committee formed to attract high teachnology and raise the level of science, reported that 90% of the mathematics teachers did not major in mathematics, and only 8% of the mathematics teachers had taken a physics course.

Devising a Plan

Minnesota "Alliance for Science" is a statewide effort aimed at grade and high schools.

Northeast Missouri State Unviersity reported success in a summer retraining program for good elementary teachers with some math background. Some district and institutional support was available and work toward certification at the junior high level was provided, with the opportunity to return in following summers to certify for grades 7-12. They also reported that the university was providing four full-ride scholarships for math-science majors who would make a two-year commitment to teaching.

The discussion leader has a grant to do public relations work in the math-science area in the rural Wisconsin schools.

Industries which rely on well-trained people could be encouraged to assist by providing summer jobs for students and teachers, providing equipment, etc.

References and Resources

Teacher Shortage and Mathematics--Myths, Realities and Research
National Institute of Education
Teachers and Instruction Division
Mail Stops
1200 19th St., N.W.
Washington, DC 20208

Helping Able Young Women Take Math and Science Seriously in School
Patricia Lund Casserly, reprinted and revised from:
New Voices in Counseling the Gifted
Kendall & Hunt Publishing Company, Dubuque, Iowa
The College Board, New York 1979

Prime 80, Proceedings of a Conference on prospects in Mathematics Education in the 1980's
Mathematical Association of America

Summary Report of the Proceedings of the Symposium on the Shortage of Certified Mathematics Teachers in the District of Columbia Public Schools
Feb. 5, 1983

Educating Americans for the 21st Century
National Science Foundation
Washington, D.C. 20550

Math and Science: Where are the Teachers
The Council for Basic Education
725 Fifteenth Street, N.W.
Washington, D.C. 20005 Sept. 83

Science & Engineering: Education for the 1980's and Beyond
National Science Foundation
Washington, D.C. 20550

Pamphlets

Parents: Protect Your Children's Future. Have Them Take Algebra and Geometry in High School
The Third College, Q-015
University of California, San Diego
La Jolla, CA 92093

A Series: "Don't Knock it. Unlock it with Math"
Mathematics Department
Minneapolis Public Schools
807 Broadway, Northeast
Minneapolis, MN 55413

# THE STATUS OF TEACHING STRATEGIES AS A BASIS FOR A THEORY OF TEACHING

Tom Cooney, Discussion Leader
University of Georgia

Lewis H. Coon, Recorder
Eastern Illinois University

The discussion leader set the stage for a discussion of teaching strategies by reflecting on the acceptance of such strategies in recent years among teachers and researchers of educational methods and in the changing strategies set forth over the years. He used quotations from Steven Brown and John Dewey to highlight such changes. He included a statement by John Locke, "A child's mind is not just a pot to be filled--but a fire waiting to be lit!" He then reviewed some of the highlights of the opening presentation by Dr. Crosswhite with examples of a clear need to delineate between the teaching strategies and skills needed by a high school beginning teacher and by an elementary beginning teacher. In one instance he spoke of the clear frustration such teachers express when they fail to grasp the details of how a child tries to solve a problem; in another, of the survival skills they both need and which should be recorded during a methods course and in observation of other, more experienced teachers.

A discussant recommended that early in teacher preparation we should examine the diverse ways in which students in differing environments perceive school from a rural, from an urban, and from a laborer's viewpoint.

Jerry Becker presented as clear evidence for the need to teach survivalskills his own personal experience as a first year teacher when his methods course background "did not meet reality--I had to survive! I stuck to the book while getting enough classroom experience to vary my methods in later years."

Katie Pedersen spoke concerning her belief that a professionalized approach to the teaching of algebra, geometry, etc. at the university level would come closer to that which we need in the high school. Tom Cooney responded with an illustration showing that geometry is difficult at the high school level (as the results of the International Study reported at this meeting indicate all too clearly) while being taught at the university level as purely theoretical.

Another discussant suggested that we should "Let our students view video tapes of our teaching as well as the teaching of others." The recorder suggested that we are being remiss when, with the technology of today, we do not let them view videotapes of the same lesson taught by widely differing approaches and by the use of differing strategies—maybe even a bank of such videotapes needs to be made and offered for duplication or sale.

Another suggested that his "40 question first day test" given and retained over the years follows the changing strategies over the years and encourages him to motivate change and to teach a methods course that is truly eclectic.

It was suggested that some of the 40 questions should be from standard secondary content and that we should teach specific high school content.

A further suggestion encouraged us to have a high school text, e.g. Algebra I, in the hands of each methods student, and that we use it for microteaching and do "lots" of such microteaching. Some of the microteaching should follow a Polya model.

Katie suggested that first year classroom management should become a unit in a methods course with other units and strategies building out from more basic needs.

At Northeast Missouri State University mathematics methods students, due to financial constraints, work as a cluster and take the methods course while student teaching.

Lewis asked for a show of hands regarding how many present were from universities where a general-subjects-supervisor supervises all student teaching. The response indicated about one-half. Thus the strategies emphasized in methods class may not be observed or encouraged during student teaching in too many situations. One participant indicated that in a small school this is necessary as she had taught math methods and then supervised all subjects during student teaching. "I didn't know the content of P.E., history, etc."

Jerry reported that in too many instances kids were a captive audience to public school teachers, student teachers and others and that this holds for our university classes and methods courses. The discussion leader quoted Silberman in response, "Maybe in Teacher Education we provided the answers without knowing the questions they may want to ask." It is well known that subjects/students who perceive themselves as expected-to-play-a-role, do so with anticipation and unrealistically.

One discussant asked if secondary preservice teachers see as many role models as do elementary preservice teachers? In the discussant's case they make it a point to provide different role models.

Another indicated that their elementary teachers have early observation and contact experiences in a classroom. Then they teach one-on-one (tutor). After which they teach to small groups of 3-4 before teaching a whole class. Their secondary preservice teachers teach 2-4 days in a low level university algebra class.

At Eastern Illinois University many of the student teachers work with at least two cooperating teachers who use different strategies and where both are successful. A diary or report discussed with the supervising teacher can bring out such differing, successful strategies.

At Southern Illinois University the cooperating teachers are carefully selected for each student teacher who then carefully control their first experiences.

Cooney asked if we are really preparing student teachers to go into a classroom—

as little league coaches do for a sports team or as any coach does where they will be a center of public attention, display, and will be expected to perform better than in practice?

In closing, several discussants reported on references which they use and which should be available for reading by students at non-class times.

David Johnson, Every Minute Counts

Charles E. Silberman, Crisis in the Classroom

Methods textbooks in use by discussants were not those expected (or desired) by the authors present.

## FIELD EXPERIENCES IN ELEMENTARY AND SECONDARY SCHOOLS

Henry Kepner, Jr., Discussion Leader
University of Wisconsin, Milwaukee

John F. Jacobs, Recorder
Central Michigan University

Field experiences for mathematics teachers in training can generally be categorized as occurring at one of three levels: A) Pre-education field experiences, typically occurring during the freshman or sophomore years, B) Methods-course related field experiences and C) Student teaching experiences.

The pre-education field experiences are typically one or two credit hour field based experiences, including on-campus seminars, designed to orient prospective teachers to the attitudes and perspectives that teachers hold rather than those with which the students are familiar from having spent most of their lives in classrooms. The value of this experience was questioned by some discussants from a cost/benefits perspective. A variety of existing simulation models were discussed that could be considered to replace this experience: Included were films, videotapes, and computer simulations. Costs, logistics and control over the nature of the experiences were among the factors considered. One considerable cost was the loss of several hours of class time for each hour in the schools. Emphasis was given to the importance of participation by the university faculty in the selection of teachers and sites for the pre-education field experience. Pre-education experiences were reported as an opportunity for prospective teachers to self-select out of an educational curriculum early in their program. Field experiences, at all three levels provide an opportunity for university faculty to involve students in professional organizations through participation in student chapters of these organizations as well as attendance at local, state and national conferences. Early pre-education experiences were also presented as an opportunity for prospective students to meet university faculty members early

in their training. This was discussed as being particularly important when student academic advisement was carried out by a system of centralized advisement.

Methods course related field experiences were reported as valuable opportunities to practice skills being developed concurrently with structured class work. Many of the same problems exist at this level as at the earlier level, but benefits accruing to future teachers weigh more heavily in the cost/benefit evaluation. Cooperation between university faculty and cooperating teachers was discussed as being critical. Such issues as approval of student developed lesson plans by both the university faculty member and the cooperating teacher, extended experiences with individual teachers, classes and students, and careful selection of sites were emphasized. The use of after school remedial/tutorial efforts, established cooperatively by the university department and public school provided significant supplementary opportunities to develop those skills being taught in methods courses at a perhaps less significant cost than more extensive involvement in the regular school programs. In connection with the methods course related experiences, attention was drawn to the opportunities for recruitment into the profession through development of and involvement in future teacher clubs in connection with all of these procedures.

The amount of time teachers in training spend in classrooms prior to their student teaching experiences were considered. Currently the State of Illinois requires a minimum of 100 clock hours including simulation experiences. The classroom experience required of teachers was contrasted with the cosmetology requirement of 1500 hours. The computerization of records throughout the pre student teaching experience was advocated. Also discussed was the load credit for university faculty supervision of these experiences. Some institutions currently allow load credit equivalent to that allotted for student teaching supervision, with supervision of six or seven teachers in training being the equivalent of teaching one course.

Relatively less consideration was given to the discussion of student teaching

experiences. A model for classroom assignments of student teachers was proposed and discussed that would allow for participation in three different courses, each for five weeks (e.g., general math, trigonometry, and geometry), plus teaching in two sections of a fourth course (e.g., algebra) for the entire semester: Allowing observation and teaching of a variety of mathematics courses, the teaching of one course for an entire semester, allowing student teachers to observe continuous learning on the part of the students, and the repetition of that experience during a second period, thereby allowing students to modify lessons and materials in order to observe the effects of such modifications.

# GOALS FOR METHODS EXPERIENCE AT THE ELEMENTARY LEVEL

Tom Pitts, Discussion Leader
Indiana State University

Gene Dolson, Recorder
Eastern Illinois University

The presider opened the session by citing the two major problems that the teacher of arithmetic faces: first, how to select, organize, and present the subject matter so that children of widely varying abilities will discover meanings and understand the work; and second, how to use instructional procedures and learning aids to effectively provide for individual differences.

The presider continued by listing goals for the methods experience at the elementary level:

1. A systematic discussion of methods of selecting and organizing the arithmetic program
2. An analysis of number operations arranged according to the pupil's arithmetic background at which he can be successfully taught
3. The sequence of the contents of arithmetic curriculum at all levels of the elementary school
4. Effective ways in which the contents of subject matter can be differentiated for pupils of various levels of ability within a class, and
5. Methods of enriching the work in arithmetic for the more able children.

Later, during ensuing discussion, the presider revealed that the opening statements were to be found in a 1959 methods text--and noted how insignificant were the changes in problems, goals and philosophical statements in the 25 intervening years.

The discussion resulted in no concrete conclusions although many valuable contributions and comparisons of interest to methods teachers were made. The topics of discussion were many and rapidly changing. A summary of these topics and contributions would include

--enrichment materials

--materials and teaching aids for individual differences

--well-grounded assumption of content before methodology

--coordinated flow of preparatory courses and the pros and cons of having the same instructor for methods and content

--enabling students to feel capable and confident of teaching elementary mathematics (overcoming their own anxieties)

--understanding the spiralling configuration underlying elementary mathematics instruction

--elementary teachers setting yearly goals on what they plan to accomplish in their mathematics classes

--comparison of approaches to peer-group/micro-teaching experiences--how many, time span, etc.

--comparison of elementary school participation while enrolled in methods classes

--much discussion on "problem solving"

--are traditional "word problems" really "problem solving"?

--do we examine scope & sequence charts with our methods classes?

--attitudes of in-service teachers enrolled in workshops and continuing education classes--especially toward topics "not in my grade level".

It was quite clear that the majority of methods teachers in attendance were pleased with their efforts in most respects but all seemed receptive to new ideas and avenues of instruction.

# DEALING WITH MATH ANXIETY IN THE PRESERVICE PROGRAM FOR ELEMENTARY TEACHERS

Daniel Keane, Discussion Leader
Bradley University

Nanette Eklund, Recorder
Luther College

The session involved much discussion of the topic in a free manner. Four main ideas were addressed. They will be reported here consecutively even though they did not occur in the discussion in such a manner.

1. What is math anxiety?

   This was introduced by our leader as having "hang-ups about math". Later identification of the topic was questioned, again, and these thoughts emerged—

   --the heartbeat goes up, hands become clammy, they seem nearly in a state of shock.

   --so frightened they seek help a semester before they begin the course.

   --say it took months to get the courage to ask for help.

   --shake in math class.

   --dread mathematics.

   --convinced they can't learn math even though they carry a 3.5 overall.

2. Society's influence on math and math anxiety.

   --Women were seen as less able in math

   --as this has begun to change those who aren't math anxious are turning to better paying jobs outside education.

   --Some seem afraid of math because they fear a "poor" grade.

   --Pre-school and kindergarten children do math easily. It seems when numerals become attached to the work that parents become frightened

   --parents and peers don't hesitate to say it's O.K. to be poor in math, which isn't true for reading or science.

--Society sees math teachers or "good" math students as elitists

--those who are "best" in any discipline are elitists

--let them see that ordinary people use math in ordinary ways.

--School counsellors let those who want to avoid math believe that they can do this through elementary education.

3. What are some ways to reduce math anxiety?

--Identify those who are anxious early and offer help and a listening ear.

--Build a trusting atmosphere so they feel they can admit anxiety.

--Get them in a group with others with the same problem so they won't feel so "strange".

--Have peers discuss ways to change their attitude toward math seeing it is something they will teach each day

--both peer and faculty counsels seem better suited to females

--anxious males express dissatisfaction in class and then leave the topic without getting help.

--Find a new way to teach math concepts which is less frightening

--then let them know they have done math well.

--Involve them in "doing" math rather then only computing or doing "mechanical" math.

--Help them identify when they began to be anxious

--so that this experience is not repeated for children

--so they can see how their anxiety could be passed on to another generation

--to prevent this, a better way to teach math will be your goal.

--Teachers can begin to say, "I don't know".

--feel free to say you <u>don't have</u> all the answers

--feel free to be different and recognize that we all learn at different rates

--feel free to let students know that teachers struggle with solutions, too

--let students help teacher or watch teacher work through a solution.

4. Cautions to providing help for anxious students

--in attempting to help them see themselves as capable we must not overlook errors in teaching

--do we overcompensate when we encourage a change in attitude by grading high

or

--do we perpetuate a negative attitude by giving an honestly earned poor grade

--this is a dilemma we have not resolved

--in an effort to help anxious students, they become more anxious knowing they have been identified.

These are issues confronted during the discussion. There <u>are</u> ways to help the math anxious if one is aware of some of the pitfalls and the influence of society as we try to help preservice elementary students deal with their anxiety. A concluding story was told of a returning student who thought he was math anxious. As he began to see how the ideas of math were as related as the ideas of his earlier undergraduate major had been he beamed and said, "Why didn't they tell me math was like this?"--a victory--the joy of teaching!

# PROBLEM SOLVING

Eugene D. Nichols
The Florida State University

Summarized by:
Robert Dentzman
Quincy College
Diane Drufenbrock, O.D.F.
St. Mary of the Woods College
Mary Rice
Mulberry Grove High School

The session began with an overview of the background and current status of problem solving. We entered the 1980's with the NCTM recommendation that problem solving be the major focus of school mathematics for this decade. Many other national commissions and committees have also put problem solving as the number one priority in teaching mathematics. Several states have taken action in giving problem solving unprecedented importance in the mathematics curriculum. The California Math Framework of 1980 said that "every topic in mathematics should derive its justification for existence in the basis of its value as an aid in problem solving." The more recent 1984 statement is even stronger: "Every lesson must start with a problem solving situation and all work to that end." The Texas Proclamation, 1983, was also very strong in its support of problem solving with the statement that "Daily classroom time should be devoted to developing problem solving techniques." Essential Elements, Texas, 1984, HB246 stated: "Problem solving situations . . . demand that the student develop a plan for the solution as well as execute the plan."

Problem solving is a composite of many abilities. Simplistic efforts to improve problem solving are not enough.

Items involved in problem analysis were spelled out. Teaching the heuristics

of problem solving will not necessarily improve problem solving abilities. Perhaps the behaviorists are right in saying that students learn only what you teach them. They can learn the heuristics of problem solving, but there is little transfer of learning: teaching heuristics produces learning heuristics, but does not generally make better problem solvers!

E. G. Begle's book, Critical Variables in Mathematics Education (1979), was highlighted and some of the findings were summarized. A mixture of abilities are needed for different classes of problems.

Several studies were mentioned regarding qualities of problem solvers, Einstellung research, and switching abilities. A study of good problem solvers reveals five characteristics, only two of which can be taught:

high IQ -- seems to be more a matter of heredity

high reasoning ability -- related to IQ

high reading and comprehension skills

high computation skills

high spatial aptitude -- according to a Rutgers seems to not be related to cultural environment.

We also cannot teach an individual how to use the knowledge that one already possesses.

Closing remarks included a quick summary of his own recent research. Interviews were conducted with 58 eighth graders on eight problems. These eighth graders have shown that they are better at solving non-routine percent problems (50% success) than for types that they were taught, but have forgotten (25%). The form of presentation of a problem has a lot to do with the student's success in solving it.

Following the presentations, invited reactions and comments were given by Katherine Pedersen, Don Balka and Diane Thiessen. Other participants were then given the opportunity to respond with questions and comments.

# IDEAS FOR TEACHING PROBLEM SOLVING

Dr. Phares G. O'Daffer
Illinois State University

## I. The Importance of Problem Solving

The importance of problem solving has been emphasized for decades. Two recent reports have dramatically re-emphasized this goal. The National Council of Supervisors of Mathematics in a position paper on basic mathematical skills published in January, 1977, states the following:

> Learning to solve problems is the principal reason for studying mathematics. Problem solving is the process of applying previously acquired knowledge to new and unfamiliar situations . . . . Problem solving strategies involve posing questions, analyzing situations, translating results, illustrating results, drawing diagrams, and using trial and error. In solving problems, students need to be able to apply the rules of logic necessary to arrive at valid conclusions. They must be able to determine which facts are relevant. They should be unfearful of arriving at tentative conclusions and they must be willing to subject these conclusions to scrutiny.

The need to improve problem solving instruction was highlighted in a report of the National Assessment of Educational Progress in Mathematics (completed in 1978) which stated:

> If it were necessary to single out one area that demands urgent attention, it would clearly be problem solving . . . . At all age levels, there appeared to be little attempt to think through a problem to arrive at a reasonable answer.

More recently the National Council of Teachers of Mathematics in its booklet entitled An Agenda for Action: Recommendations for School Mathematics of the 1980s strongly recommended that "problem solving be the focus of school mathematics in the 1980s."

These are only a few of the many voices exhorting classroom teachers to better help students learn to solve problems. Perhaps our position is humorously presented in the following verse from Grooks by Piet Hein.

> We will have to produce problem solvers galore
> For each problem solved creates 10 problems more.

## II. Some Important Ideas

### A. What is a PROBLEM?

Here are two definitions. Take your pick or devise your own.

1. A real problem for an individual is a question which

   a. presents a challenge,

   b. cannot be resolved by some routine procedure known to the individual, and

   c. where the individual accepts the challenge.

2. In the elementary school a problem is a situation given to a student, usually by a teacher, where the student must use one or more solution strategies in order to answer a question or make a decision.

B. What are some **TYPES OF PROBLEMS**?

1. ONE-STEP

   Solved using a single operation (+, −, x, ÷)

   Example: A jet plane has 214 seats. 167 people got on. How many seats are empty?

2. MULTIPLE-STEP

   Solved using 2 or more operations (+, −, x, ÷)

   Example: An old U.S. flag had 4 rows of stars with 7 in each row and one row with only 6 stars. How many stars did it have?

3. PROCESS

   Cannot usually be solved by simply using one or more operations. Often requires other strategies.

   Example: 6 people each ride the roller coaster with each other person only once. How many rides?

4. PUZZLE

   Requires a flash of insight or a lucky guess.

   Example: Can you make 4 congruent triangles with 6 toothpicks?

5. APPLIED

   Requires organization, analysis of data, problem selection, and a variety of skills—a realistic problem.

   Example: How much should you charge for lemonade to make a profit at your lemonade stand?

C. What is **PROBLEM SOLVING**?

Problem solving is a process which includes the components on the following problem-solving checklist.

1. Understand the QUESTION

   (Also understand the problem conditions and variables.)

2. Find the Needed DATA

   (Data may need to be collected from a variety of sources such as books, interviews, experiments, advertisements, catalogs, computer data banks, etc.)

3. Plan What to Do

   (Select appropriate sub-goals and strategies; implement the strategies to attain the sub-goals.)

4. Find the ANSWER

   (A variety of means such as mental calculation, use of calculator, use of computer, logical reasoning, etc., may be needed to find the answer.)

5. CHECK BACK. Does the Answer Make Sense?

   (Reread the problem, use estimation to evaluate the reasonableness of the answer, give the answer in terms of the problem data using a complete sentence.)

D. What are some STRATEGIES for solving process problems?

The following strategies are among those used most often by elementary school children to solve process problems.

1. GUESS AND CHECK ? ✓

2. DRAW A PICTURE

3. MAKE A TABLE

| | | | | |
|---|---|---|---|---|
| miles | 3 | 6 | | |
| km | 5 | 10 | | |

4. LOOK FOR A PATTERN 1, 1, 2, 3, 5, ___, ___, ___

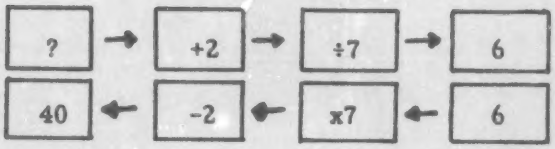
5. MAKE AN ORGANIZED LIST

AB BC CD
AC BD
AD

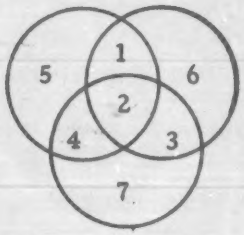
6. WORK A SIMPLER PROBLEM

30 tables? 2 tables 6

7. WORK BACKWARD




8. USE LOGICAL REASONING




9. WRITE AN EQUATION $2x + 5 = 11$

## III. Some Problem Solving Teaching Techniques for Teachers

### A. PLANNING for a Problem Solving Experience

Teaching problem solving can be a comfortable, interesting and enjoyable experience for teachers if they have a good source of problems, a definite plan for when to use them, and an easily used technique for making plans and for guiding students through a process problem solving experience. The following teaching actions, adapted from the book Teaching Problem Solving: What, Why and How by Charles and Lester (Dale Seymour Publications), provide valuable specific helps for teachers in making these plans.

TEACHING ACTIONS

BEFORE

TA 1. Read the problem to the class or have a student read the problem. Discuss words, phrases or ideas students may not understand.

TA 2. Use a whole-class discussion to help students understand the conditions and variables in the problem. Ask questions (give hints) for understanding the problem. Have these questions written out in advance in section 1 of the Problem Solving Lesson Plan Form.

TA 3. Ask students which strategies might be helpful for finding a solution. Do not evaluate students' suggestions. Have a list of problem solving strategies on the bulletin or chalkboard when asking for suggestions.

DURING

TA 4. Observe students as they work in groups of three or four and provide clarification as needed.

TA 5. Ask questions (give hints) for solving the problem as needed. Have these questions prepared in advance on section 2 of the Problem Solving Lesson Plan form. Repeat the understanding hints from section 1 as needed.

TA 6. Require students who obtain a solution to check their work and answer the problem. Be sure they are confident about the reasonableness of the answer and write it using a complete sentence.

TA 7. Give a problem extension to students who complete the original problem much sooner than others. Select or create the problem extension in advance in section 3 of the Problem Solving Lesson Plan form.

AFTER

TA 8. Show and discuss students' solutions to the original problem. Have students name the strategies used. Reinforce the names of the strategies by pointing out the strategy names on the bulletin board.

TA 9. Discuss special features of the original problem (if any). Note these in section 4 of the Lesson Plan Form in advance or as you observe students working the problem.

TA 10. Relate the problem to previous problems solved (if possible) and solve and discuss the extension of the original problem.

The Lesson Plan Form mentioned above is presented on the following page. Two sample lesson plans are given, followed by two problems for which you may wish to write a plan.

## PROBLEM SOLVING LESSON PLAN

PROBLEM:

1. READ PROBLEM, DISCUSS. ASK QUESTIONS FOR UNDERSTANDING.

   a.

   b.

   c.

   Possible Strategies?

2. ASSIGN PROBLEM, OBSERVE. ASK QUESTIONS (GIVE HINTS) FOR SOLVING.

   a.

   b.

   c.

   Have Students Check and Give Answer.

3. ASSIGN EXTEENSION PROBLEM - IF NEEDED.

4. DISCUSS SOLUTION(S), STRATEGIES, SPECIAL FEATURES, RELATED PROBLEMS, ETC.

## PROBLEM SOLVING LESSON PLAN

PROBLEM:

Ted has $3 more than Jane. The sum of their amounts if $15. How much money does Jane have?

1. READ PROBLEM, DISCUSS. ASK QUESTIONS FOR UNDERSTANDING.

   a. Who has more money? (Ted) Who has less money? (Jane)

   b. How much more money does Ted have? ($3)

   c. How much do they have together? ($15)

   d. What are we trying to find? (how much money Jane has)

   Possible Strategies? Guess and Check

2. ASSIGN PROBLEM, OBSERVE. ASK QUESTIONS (GIVE HINTS) FOR SOLVING.

   a. Would it help to guess, then revise your guess?

   b. Suppose Jane had $7. How much would Ted have? (7 + 3, or $10)
      How much altogether? ($17)

   c. Was your guess too high or too low? (too high)

   d. What is your next guess?

   Have Students Check and Give Answer.

3. ASSIGN EXTENSION PROBLEM - IF NEEDED.

   Adult tickets cost $6 and children's tickets cost $4.
   Jenny sold 13 tickets for $66. How many adult tickets did she sell?

4. DISCUSS SOLUTION(S), STRATEGIES, SPECIAL FEATURES, RELATED PROBLEMS, ETC.

   Guess & Check: Jane: $6; Check, Ted: 6 + 3 or $9; Total, 9 + 6 or $15. Jane had $6.

   OR

   Choose the Operation: 15 - 3 = 12, 12 ÷ 2 = $6. Jane had $6.

   OR

   Write an Equation: J + J + 3 = 15, 2J = 12, J = 6
   Jane had $6.

   **Note:** Some students treat the problem as a multiple step problem and solve as shown here.

## PROBLEM SOLVING LESSON PLAN

Problem:

Each of 8 friends takes one "bicycle built for two" ride with everyone else. How many bike rides do they take?

1. READ PROBLEM, DISCUSS. ASK QUESTIONS FOR UNDERSTANDING.

   a. How many friends were there? (8)

   b. What were they doing? (riding a bicycle built for 2)

   c. If A rides with B, will they ride together again? (no)

   d. Is "A rides with B" the same ride as "B rides with A"? (yes)

   Possible Strategies? Make an Organized List, Make a Table, Draw a Diagram, Look for a Pattern

2. ASSIGN PROBLEM, OBSERVE. ASK QUESTIONS (GIVE HINTS) FOR SOLVING.

   a. Suppose there were only 2 friends. How many rides? (1) 3 friends? (3) 4 friends? (6)

   b. Would it help to make a table? Do you see a pattern?

   or

   c. Suppose person A takes all his rides first. How many? (7)

   d. If B goes next, how many rides will she take? (6, B has already ridden with A)

   e. Would it help to make an organized list?

   Have Students Check and Give Answer.

3. ASSIGN EXTENSION PROBLEM - IF NEEDED.

   Suppose the 8 friends were 5 boys and 3 girls. If only boys and girls rode together, how many rides were taken? (Solution: 5 x 3 = 15)

4. DISCUSS SOLUTION(S), STRATEGIES, SPECIAL FEATURES, RELATED PROBLEMS, ETC.

   Make a Table:

| # of friends | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| # of rides | 1 | 3 | 6 | 10 | 15 | 21 | 28 |
| | | +2 | +3 | +4 | +5 | +6 | +7 |

28 rides were taken

OR

Make an Organized List:

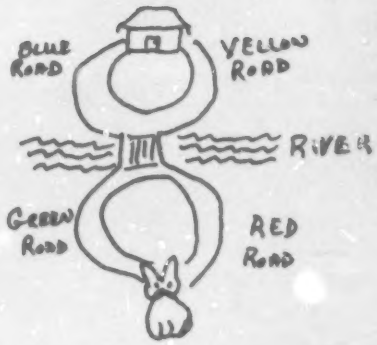
| | | | |
|---|---|---|---|
| A, B C D E F G H | 7 | E, F G H | 3 |
| B, C D E F G H | 6 | F, G H | 2 |
| C, D E F G H | 5 | G, H | 1 |
| D, E F G H | 4 | H | |
| | Total | | 28 |

**Note:** Some students feel that "A rides with B" is a different ride than "B rides with A".

## PROBLEM SOLVING LESSON PLAN

PROBLEM:

How many different ways can the bunny go to grandma's house?




1. READ PROBLEM, DISCUSS. ASK QUESTIONS FOR UNDERSTANDING.

   a.

   b.

   c.

   Possible Strategies?

2. ASSIGN PROBLEM, OBSERVE. ASK QUESTIONS (GIVE HINTS) FOR S VING.

   a.

   b.

   c.

   Have students Check and Give Answer.

3. ASSIGN EXTENSION PROBLEM - IF NEEDED.

4. DISCUSS SOLUTION(S), STRATEGIES, SPECIAL FEATURES, RELATED PROBLEMS, ETC.

## PROBLEM SOLVING LESSON PLAN

PROBLEM:

A snail is at the bottom of a 10 ft. well. Each day it climbs up 5 ft. But at night, while sleeping it slides back 4 feet. At this rate, how many days will it take the snail to get out of the well?

1. READ PROBLEM, DISCUSS. ASK QUESTIONS FOR UNDERSTANDING.

   a.

   b.

   c.

   Possible Strategies?

2. ASSIGN PROBLEM, OBSERVE. ASK QUESTIONS (GIVE HINTS) FOR SOLVING.

   a.

   b.

   c.

   Have Students Check and Give Answer.

3. ASSIGN EXTENSION PROBLEM - IF NEEDED.

4. DISCUSS SOLUTION(S), STRATEGIES, SPECIAL FEATURES, RELATED PROBLEMS, ETC.

B. Suggestions for GROUPS

As students work in groups of three or four in problem solving situations, it is more easy to monitor and assess their performance. Pressure on individual students is reduced and better attitudes toward problem solving are developed as students learn to communicate in groups and have a greater opportunity to become involved in a discussion of the problem solving situation. As a teacher appoints a group leader and a recorder, it may be useful to establish the following ground rules (or adaptions thereof) for group work.

1. Be Involved in Your Group.

   Don't be afraid to talk. Don't eavesdrop on other groups.

2. Be/Use a Source of Help.

   You must be willing to help anyone who asks. You must ask for help if you don't understand.

3. Ask Only Group Questions.

   Don't ask teacher questions unless all 4 have the same question.

4. Give Only Group Answers.

   Be sure all four agree on an answer before announcing that your group has the answer.

C. Develop a POSITIVE CLASSROOM ATMOSPHERE

One of the major goals for teaching problem solving is to help students develop positive attitudes toward their problem solving abilities and experiences. The following suggest some ways to develop a special "problem solving spirit" in your classroom that will help meet this goal.

1. Be Enthusiastic.

2. Personalize Problem Solving.

3. Promote Success.

4. Reward the Right Things.

John Holt said, "The classroom has become a temple of worship for the right answer and the way to get ahead is to lay plenty of them on the altar." What shall we reward to encourage the development of students' problem solving ability? The following list of attitudes or actions to reward seems an appropriate beginning.

1. Willingness to Try — to take a risk

2. Perseverance — to "stick to it"

3. Patience — to be persistent, not necessarily speedy

4. Flexibility — to try different approaches

5. Self-Reliance — to rely on own check, not the teacher's O.K.

6. Attention to Strategies — to choose and use strategies

7. Focus on Process — to place "getting the answer" in proper perspective

8. Effective Communication — to talk about approaches and solutions

9. Thinking — to use non-algorithmic thinking when appropriate

D. Thoughts about EVALUATION

The student's problem solving performance can be evaluated by analyzing written work, observing the student in whole class or small group problem solving activities, and by interviewing the student individually.

A teacher may wish to evaluate only two or three students in a given problem solving experience. As the teacher observes these students and their work they may wish to devise their own evaluation scheme to answer the following questions.

1. How well can the student do the following?

   a. Understand the question

   b. Understand the problem conditions, variables

   c. Select needed data

   d. Select appropriate subgoals and strategies

   e. Implement strategies to attain subgoals

   f. Give answer in terms of problem data

   g. Evaluate the reasonableness of an answer

2. How effective is the student in finding the correct answer?

## IV. Some Sample Problems for Elementary School Children (Grades 3 and Up)

A. Nancy planned to mow 6 lawns each day she worked in the summer. Scott decided to mow 5 lawns each day. When Nancy has mowed 42 lawns, how many will Scott have mowed?

B. Ted has $3 more than Jane. The sum of their amounts is $15. How much money does Jane have?

C. In Terri's class, 16 children play on the soccer team and 18 play on the volleyball team. Of these children, 6 play both soccer and volleyball. How many children are in the class if everyone is on at least one team?

D. If Cathy made 3 free throws out of every 5 shots during the basketball season, how many free throws would you expect her to make in 30 shots?

E. A T-shirt shop had only these numerals left: 1, 5, 8, 9. How many different 2-digit numbers can Nan choose for the back of her shirt?

F. Jill spent ½ of her money in a store. She then went to another store and spent ½ of what was left. After than she had 24¢. With how much money did she start?

G. Thirty small square tables were needed for a banquet. Each table can seat only one person on a side. If the tables were pushed together to make a long table, how many people could sit at the banquet table?

H. Each of 8 friends takes a "bicycle built for two" ride with everyone else. How many bike rides do they take?

I. One morning a snail starts climbing up a pole 10 m high. Each day it climbs 2 m. Each night it slips back 1 m. On what day--8th, 9th or 10th--does it reach the top?

J. Sally, Gwen, Darlene, and Lana were roommates. They were from Los Angeles, Washington, Pittsburgh, and Seattle. Darlene is from Pittsburgh, Gwen is not from Seattle. If Lana is from Los Angeles, where is Sally from?

K. How much will it cost to wallpaper the room where you sleep?

L. What can you predict your weight and height will be when you are 25 years old? (Suppose tables of growth rates are available.)

M. There are 8 balls, all the same weight except one that is heavier. How can you find the heavier ball using a balance only two times?

N. How can you form 4 triangles using 6 toothpicks?

**Useful Problem Solving References for Teachers**

1. Charles, R., and Lester, F. Teaching Problem Solving: What, Why and How. Palo Alto, California: Dale Seymour Publications, 1982.

(A good review of problem solving ideas and problem solving needs in the elementary school and excellent practical suggestions for developing a problem solving program.)

2. Charles, R. and others. Problem Solving Experiences in Mathematics (Books 1-8). Menlo Park, California: Addison-Wesley, 1985.

(Numerous problems and problem solving skill development activities for grades 1-8.)

3. Dolan, D., and Williamson, J. Teaching Problem-Solving Strategies. Menlo Park, California: Addison-Wesley, 1983.

(Problem skill development, activities, practice problems, and strategy development lessons for teaching problem solving in grades 6-10.)

4. Greenes, C.; Spungin, R.; and Dombrowski, J. Problem-Mathics. Palo Alto, California: Creative Publications, 1977.

(A resource for process problems or for problems to enrich a basic problem solving program. Problem solutions carefully analyzed and extended.)

5. Krulik, S., and Rudnick, J. Problem Solving: A Handbook for Teachers. Boston: Allyn and Bacon, Inc., 1980.

(Suggestions for teaching problem solving. Several problems are discussed and analyzed.)

6. National Council of Teachers of Mathematics. Arithmetic Teacher, Focus Issue on Teaching Problem Solving, February 1982. Reston, Virginia: NCTM, 1982.

(Ideas for teaching problem solving at all levels.)

7. National Council of Teachers of Mathematics. Problem Solving in School Mathematics (1980 Yearbook). Reston, Virginia: NCTM, 1980.

(An analysis of problem solving issues and some practical suggestions for problem solving instruction.)

8. O'Daffer, P., and Clemens, S. Geometry: An Investigative Approach and Laboratory Investigations in Geometry. Menlo Park, California: Addison-Wesley, 1976.

(Sources of activities and problems involving geometry for middle grades, junior high, and secondary level students.)

9. Ohio Department of Education. Problem Solving--Becoming a Better Problem Solver (1) and Problem Solving--A Resource for Problem Solving (2). Palo Alto, California: Dale Seymour Publications, n.d.

(A discussion of problem solving in the elementary and junior high school. Good pedagogical suggestions and numerous problems analyzed according to strategies used in solutions.)

10. Sallee and Meyers. Make It Simple. Menlo Park, California: Addison-Sesley, 1984.

(Good source of ideas for teaching problem solving as well as an analysis of a number of problems for classroom use.)

11. Schaaf, W. Problem Solving in Mathematics. Lane Educational Service District, Lane Math Project, P. O. Box 2680, Eugene, Oregon 97402.

(A description of a problem solving project conducted in Oregon. Contains ideas for developing a problem solving program and a good collection of problems.)

12. TIPS Problem Solving Card Decks. Palo Alto, California: Dale Seymour Publications, 1982.

(Card decks which provide numerous problems appropriate for a variety of grade levels.)

MATHEMATICS 389.45

TEACHING PROBLEM SOLVING IN SCHOOL MATHEMATICS
COURSE INFORMATION

Section 1 11:00 - 11:50 M,W,F Room: STV 310 Fall Semester, 1984

I. Instructor: Dr. Phares G. O'Daffer
Office: 329C Stevenson Hall
Office Hours: 10:00 - 11:00 MWF or by appointment
Phone: Office 438-7302
Home 452-5909

II. Text Materials

A. Text

Teaching Problem Solving: What, Why and How by R. Charles and F. Lester (Dale Seymour Publications, 1982).

B. Materials Fee

There will be a materials fee of $6.00 per student to help defray the cost of paper and Xeroxing for course handouts, or for other materials. This fee is due Friday, August 31.

III. General Objectives of the Course

A. Knowledge about Problem Solving

1. to tell the meaning of a problem and problem solving

2. to tell the role of problem solving in mathematics education

3. to identify the different types of problems and state the purpose of each type

4. to identify factors that affect problem solving performance

5. to identify factors that affect problem complexity

6. to identify current instructional material and resources for teaching problem solving

7. to describe some teaching suggestions derived from research on the teaching and learning of problem solving

B. Teaching Problem Solving

1. to identify goals for teaching problem solving (at different grade levels)

2. to identify problem-solving strategies appropriate for different grade levels

3. to categorize problems by solution strategy

4. to sequence problems (from easy to difficult)

5. to write hints and questions for helping children to understand problems and to develop, implement, and evaluate solution strategies

6. to write (different types of) problem extensions

7. to identify specific teaching actions for teaching the different types of problem-solving experiences

8. to evaluate problem solving performance

9. to evaluate and use instructional material for problem solving

10. to identify ways to meet individual needs related to problem solving

C. Solving Problems

1. to improve one's ability to solve problems

2. to improve one's ability to reflect on problem solutions

IV. Tentative Course Outline

A. Introduction to Problem Solving

1. What is a Problem? Problem Solving?
2. Why is Problem Solving Important in Mathematics?
3. Goals for Problem Solving (Personal, Student)

B. Classification of Types of Problems

1. Simple Translation
2. Complex Translation
3. Process
4. Applied
5. Puzzle
6. Other

C. Some General Heuristics for Solving Problems

1. Polya's Guidelines
2. A 5-Point Checklist with Emphasis on Dealing with Data
3. A Problem Solving Guide
4. Other Maxims

D. Developing and Using Problem Solving Strategies

1. Choose the Operation(s)
2. Guess and Check
3. Make a Table
4. Look for a Pattern

5. Make an Organized List
6. Write an Equation
7. Use Logical Reasoning
8. Solve a Simpler or Similar Problem
9. Draw a Picture
10. Use Models, Act Out
11. Work Backward
12. Other Strategies

E. Problem Solving Follow-up Techniques

1. Analyzing Solutions
2. Looking for Atlernate Solutions
3. Extending Problems
4. Posing Related Problems

F. Analyzing/Evaluating Problem Solving Performance

1. Factors Affecting Problem Solving Performance
2. Factors Affecting Problem Difficulty
3. Observation/Interview Techniques
4. Evaluation Checklist
5. Test Items

G. Teaching Problem Solving

1. Scope and Sequence
2. Analyzing Textbooks
3. Planning Problem Solving Lessons
4. Time Utilization
5. Grouping Procedures
6. Attitudes and Classroom Climate
7. Meeting Individual Differences

H. Evaluating Instructional Resources and Materials

1. Criteria and Checklist
2. Audiovisual Resources (films, filmstrips, videotapes, etc.)
3. Computer Software for Problem Solving
4. Problem Solving Cards, Booklets, etc.
5. Posters, Bulletin Boards, Problem Solving Corner
6. Other Instructional Aids

I. Research on Teaching and Learning Problem Solving

1. Analysis of Selected Research
2. Problem Solving Research Implications for the Classroom Teacher
3. Action Research Opportunities

V. Evaluation (See accompanying description of course assignments.)

| | | Points | Percent (%) |
|---|---|---|---|
| 1. | Midterm Exam | 40 | 16 |
| 2. | Final Exam (Wednesday, Dec. 12, 1:00 p.m.) | 50 | 20 |
| 3. | Problem Set | 35 | 14 |
| 4. | Project | 30 | 12 |
| 5. | School Experience | 30 | 12 |
| 6. | Problem Solving Lesson Plans | 25 | 10 |
| 7. | Article Card File | 25 | 10 |
| 8. | Attendance and Participation | 15 | 6 |
| | | 250 | 100 |

*Students taking this course for graduate credit will have an additional assignment.

MATHEMATICS 389.47 P. O'Daffer

TEACHING PROBLEM SOLVING IN SCHOOL MATHEMATICS
COURSE ASSIGNMENTS

A. Problem Set

1. Beginning August 31, you will be required to turn in 2 problems each week for 10 weeks or a total of 20 problems.

2. Both problems should be printed/typed on 5" x 8" cards. For each problem you must provide 6 pieces of information.

   a. at least one complete solution, not just the answer

   b. the names of the solution strategies listed in order from "most likely children will use" to "least likely children will use"

   c. the problem theme (real-world situation)

   d. the mathematical content

   e. the grade level (primary or intermediate/JHS)

   f. difficulty level (easy, average, or difficult)

   The format for the problem cards is given on an attached sheet.

3. Problem sources

   a. One problem can be "borrowed" from another source or can be a variation of a problem found in another source. Note the source of the problem and whether it is exact or a variation.

   b. One problem must be original. This should also be noted in the problem source space.

4. One problem should be for the primary (grades 1 or 2) and one should be for the intermediate/JHS grades (grades 3-8).

5. Each week, you should identify which of the two problems you think is "best." This problem should be written on a ditto and turned in with the two cards. You will be given dittos for these problems.

6. Each week, you will be told the strategy to be focused on and the content area for the next week's two problems.

7. Grading - 35 points total

   Each week you will be given 0, 1, 2, or 3 points for the problem cards you hand in. After 10 weeks you could have a maximum of 30 points. At that time, up to 5 additional points will be possible for the overall quality of the complete set. The cards will be evaluated on the basis of the quality of the problems, the quality of the solutions, and the appropriateness of the other information on the cards.

B. Project

1. You must complete an individual project designed to help you teach problem solving. The project should result in some type of instructional material that is "ready to use." Samples will be shown in class. Here are some possible projects.

   - Develop a problem solving bulletin board which involves the children.
   - Develop a problem solving resource center (card boxes, folders, games, etc.).

2. Your project should have these characteristics:

   - at least 5 process problems and at most 5 problems of other types; 10 "experiences" in all as a minimum
   - designed for independent problem solving (perhaps pairs)
   - hints (and the answers) should be available
   - a complete solution (with strategy names) should be given
   - an extension should accompany each problem (and its solution)

3. Grading - 30 pts. total; maximum of 5 in each of these areas:

   appropriateness for children at designated grade level
   appearance and durability
   ease of use
   creativity/originality
   quality of problems
   quality of hints, solutions, and extensions

C. School Experience

1. We will have at least 2 in-school experiences related to problem solving.

2. One of these will focus on observing children while they solve problems. The other will focus on instruction. (See attached sheets, parts 1 and 2 for descriptions.)

3. Grading - 30 points total (15 points for each part. Criterion will be given later.)

D. Problem Solving Lesson Plans

1. Use 4 of your "best" problems from the problem set you develop.

2. For each problem, you will complete a problem solving lesson plan form. For each you will write

   a. 3 "understanding" questions
   b. 2 "solving the problem" questions

c. the solution (not just the answer)
d. 2 problem extensions (2 different types)

3. Grading - 25 points total

quality of problems selected (5 pts. maximum)
quality of hints (10 pts. maximum)
quality of extensions (10 pts. maximum)

E. Card File

1. Article Card File. Read at least 6 articles on problem solving from journals such as the Arithmetic Teacher, Instructor, Learning, etc., and prepare a card (or cards) for each article including the following:

a. bibliographic data about the article, i.e., title, author, journal page(s), date, etc.

b. a summary of the key important ideas in the article, including techniques for teaching problem solving, etc., that would be helpful to you as a classroom teacher.

2. Grading - 25 points total; 5 points maximum in each of the following areas:

a. quality of articles selected

b. usefulness of ideas summarized

c. evidence of your thoughtfulness in comments about major points in the article

d. variety of articles selected

e. appropriateness , quality of ideas summarized

MATHEMATICS 389.47 P. O'Daffer
Fall, 1984

TEACHING PROBLEM SOLVING IN SCHOOL MATHEMATICS
REQUIREMENTS FOR GRADUATE CREDIT

1. Complete all requirements given to the undergraduate students in the course.

2. Submit a 5-7 page (double-spaced, typed) paper giving "tips for teaching problem solving."

   a. These tips should be taken from the references given below. The source for each tip should accompany it together with any comments needed to clarify the tip.

   b. The paper will be graded on a scale of 1 to 10 points on the following basis:

      completeness/accuracy - 5 points
      usefulness to another teacher - 5 points

   c. The paper should be turned in no later than December 7.

References (on reserve in STV 302)


1. Charles, R. I. & Lester, F. K. An evaluation of a process-oriented instructional program in mathematical problem solving. The Journal for Research in Mathematics Education, 15(1), 1984, 15-34.

2. Cohen, S. A. & Stover, G. Effects of teaching sixth grade students to modify format variables of math word problems. Reading Research Quarterly, 16(2), 1981, 175-200.

3. Johnston, J. H. & Markle, G. C. What research says to the practitioner. Middle School Journal, November 1981, 22-24.

4. Lester, F. K. Ideas about problem solving: A look at some psychological research. Arithmetic Teacher, 25(2), 1977, 12-14.

5. Suydam, M. Untangling clues from research on problem solving. In S. Krulik & R. Reys (Eds.), Problem solving in school mathematics (Yearbook). Reston, Virginia: NCTM, 1980, 34-50.

## PROBLEM CARDS (5" x 8")

Front

**PROBLEM:**

ART
(if any)

**SOLUTION(S):**

Source: _____ Name: _____

Back

1. Theme:

2. Mathematical content:

3. Grade level (primary or intermediate):

4. Difficulty level (easy, average, or difficult):

5. Strategy name(s):

MATHEMATICS 389.47 P. O'Daffer
Fall, 1984

TEACHING PROBLEM SOLVING IN SCHOOL MATHEMATICS
SCHOOL EXPERIENCE - PART I: STUDENT INTERVIEWS

1. Purpose. To observe and interview a small group of children while they solve problems.

2. Problems. Select 4 or 5 problems appropriate for the students you will be working with. Be sure you have some problems you feel will be relatively easy and some that will be more challenging. Include at least 1 problem that you feel is a real challenge for these students. Sequence your problems from easy to difficult. After using the first problem, decide which of the others you might try next and so on.

3. Number of Students. Ideally you should work with a group of 2 students. In no case use more than 4.

4. Preparation. Have a copy of each problem for the students to read and paper for them to write on. Be sure you have worked through the solution to every problem.

5. Time. Allow 1 class period (approximately 40 minutes) for the interview. Comlete as many problems as possible during that time.

6. Actions During the Problem Solving Session

   a. Begin by telling the children that you are part of a team writing some math story problems for children in grade x and that they are going to help you by solving some problems.

   b. Tell the students that they are not going to get a grade for their work, but they are to do the best they can.

   c. Tell them that you want them to think out loud as they solve the problem; that they can talk to each other as much as they wish; and that they should all agree on the solution.

   d. Tell them that you are there to observe not to teach so if they get stumped, they should try to figure out what to do on their own.

   e. If students are stumped and cannot go on, give them a hint but, only do this as a last resort.

   f. Take notes on the observation forms during the interview. Finalize your notes after the session.

   g. If students work silently, encourage them to think out loud.

7. Final Interview

   a. Allow 5-8 min. for a wrap-up session.

   b. First have each student complete an attitude questionnaire. Tell them you want to see how they feel about problem solving and you would like them to answer some questions for you. They need not place their names on the form.

c. After this is completed, just talk with the students about problem solving. Here are some topics you might explore. (1) What kinds of problems do they like best? (2) Do they do a lot of problem solving in school? (3) What techniques or strategies help them solve problems? (4) What kinds of things do they think about when they solve problems?

MATHEMATICS 389.47 P. O'Daffer
Fall, 1984

TEACHING PROBLEM SOLVING IN SCHOOL MATHEMATICS
SCHOOL EXPERIENCE - PART 2: TEACHING PROBLEM SOLVING

1. Purpose. To teach a problem solving lesson to a small group of children.

2. Number of Students. You may wish to work with 3 or 5 children. If the opportunity is available and you feel ready, a whole class is OK.

3. Problems. Select 2 process problems appropriate for the students with whom you will be working.

4. Lesson Plans. Complete the lesson plan forms for each problem. Write the hints and questions for understanding the problem and solving the problem. Show at least one solution and include at least one problem extension.

5. Introducing the Lesson.

   a. Begin by telling the children that you are part of a team writing math story problems and they are going to help you by solving some problems.

   b. Tell the students that they are not going to get a grade for their work, but they are to do the best they can.

6. Teaching the Lesson.

   a. Use the teaching strategy we used and discussed in class and that you observed on the video tape.

   b. Make a copy of the Problem Solving Guide for the group or for each child.

7. Time. Allow approximately 45-60 min. for dealing with the two problems. Keep students moving so you do not spend the entire time on one problem.

8. Post-instruction Summary. Write a brief summary of the lesson immediately after you finish.

   a. Note revisions you would make in the lesson plan, if any (e.g., additional hints, different extension).

   b. Comment on the success of the lesson. In particular, discuss the usefulness of the teaching actions—what was helpful, what wasn't helpful, your evaluation of the students' work on the problems, and so on.

**EASTERN ILLINOIS UNIVERSITY**
**THE FOURTH MATHEMATICS METHODS CONFERENCE**
**June 28 - 30, 1984**
**CHARLESTON, ILLINOIS 61920**

D. F. Abell
Eastern Illinois University
R. R. #1, Box 255
Charleston, IL 61920

Haldon Anderson
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Don Balka
Saint Mary's College
Notre Dame, IN 46556

Edna Bazik
Illinois State University
202 Riss Drive
Normal, IL 61761

Susan Beal
Saint Xavier College
5537 S. Hyde Park Blvd.
Chicago, IL 60637

Jerry Becker
CIM Dept.
Southern Illinois University
Carbondale, IL 62901

Manfred Boos
Concordia College
1018 South Home Avenue
Oak Park, IL 60304

Sue Boren
Department of Mathematics
University of Tennessee at Martin
Martin, TN 38238

Mervin Brennan
Illinois State Board of Education
100 North First
Springfield, IL 62777

Frederick Brumbaugh
Ball State University
4116 North Lancaster Drive
Muncie, IN 47304

W. Jack Bush
Mathematics Department
Southwest Missouri State University
Springfield, MO 65804

Elizabeth Carpentier
Springfield College in Illinois
1400 North Fifth Street
Springfield, IL 62702

Ruth Champagne
Archdiocese of Chicago
5801 South Dorchester Avenue
Chicago, IL 60637

Lewis Coon
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Tom Cooney
University of Georgia
345 Segrest Circle
Athens, GA 30602

Patrick Coulton
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

F. Joe Crosswhite
The Ohio State University
1350 Stoneygate Lane
Columbus, OH 43221

Russel Day
Illinois Central College
1401 Westgate Road
Washington, IL 61571

Robert Dentzman
Quincy College
Quincy, IL 62301

Suhrit Dey
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

A. J. DiPietro
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Gene Dolson
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

John Dossey
Department of Mathematics
Illinois State University
Normal, IL 61761

Floyd Downs
3334 Verdun Avenue
San Mateo, CA 94403

Diane Drufenbrock
St. Mary of the Woods College
1350 Elm Street
Terre Haute, IN 47807

Edwin Ecker
MacMurray College
Jacksonville, IL 62650

Nanette Eklund
Luther College
R. R. 2, Box 60
Decorah, IA 52101

James Elander
North Central College
Naperville, IL 60566

Fred Flener
Northeastern Illinois University
13 Third Street
Park Ridge, IL 60068

Max Gerling
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Ronald Gray
Trevecca Nazarene College
3149 Goodwin Drive
Nashville, TN 37217

Sr. James Marie Gross
Clarke College
2360 Carter Road
Dubuque, IA 52001

Janet Hartman
University of Evansville
P. O. Box 329
Evansville, IN 47702

Carla Hillman
Black Hawk College
Box 122
Cerro Gordo, IL 61818

John Jacobs
Central Michigan University
307 Ronan Hallion
Mt. Pleasant, MI 48859

Wilburn Jones
Department of Mathematics
Western Kentucky University
Bowling Green, KY 42101

Michael Kasper
Purdue University North Central
3621 Ponchartrain Trail
Michigan City, IN 46360

Daniel Keane
College of Education
Bradley University
Peoria, IL 61625

Robert Kellems
Indiana State University
2607 Crawford Street
Terre Haute, IN 47803

Henry Kepner
Department of Curriculum & Instruction
University of Wisconsin - Milwaukee
Milwaukee, WI 53201

Lloyd Koontz
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Claire Krukenberg
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Jon Laible
Dean of Arts & Sciences
Eastern Illinois University
Charleston, IL 61920

John LeDuc
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Anne Madsen-Nason
Michigan State University
914 Woodbine Blvd.
Jackson, MI 49203

Curtis McKnight
Mathematics Department
University of Oklahoma
Norman, OK 73019

Loretta Meeks
Sangamon State University
29 Friars Lane
Springfield, IL 62704

Wendell Meeks
Illinois State Board of Education
29 Friars Lane
Springfield, IL 62704

Roy Meyerholtz
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Leona Mirza
North Park College
5125 North Spaulding
Chicago, IL 60625

Milton Mitchell
Mathematics Department
University of Wisconsin - Platteville
Platteville, WI 53818

Larry Mooney
Rome Grade School
509 North Street, R. R. #1, Box 358
Dix, IL 62830

Eugene Nichols
The Florida State University
3386 West Lake Shore Drive
Tallahassee, FL 32312

Phares O'Daffer
Illinois State University
1021 Gregory
Normal, IL 61761

Keith Peck
Northeast Missouri State University
Rt. 4
Kirksville, MO 63501

Katherine Pedersen
Mathematics Department
Southern Illinois University
Carbondale, IL 62901

David Pelzl
Dr. Martin Luther College
316 Hollywood Avenue
New Ulm, MN 56073

Peter Pereira
DePaul University
2323 North Seminary
Chicago, IL 60614

Charles Pettypool
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Paul Phillips
Southern Illinois University
1724 Scovel Street
Alton, IL 62002

Tom Pitts
Indiana State University
Terre Haute, IN 47809

Mary Rice
Mulberry Grove High School
214 South First
Greenville, IL 62246

Alice Robold
Mathematical Sciences
Ball State University
Muncie, IN 47306

Alfred Schmidt
Rose-Hulman Institute of Technology
7021 Wabash Avenue
Terre Haute, IN 47803

Donna Siemro
Governors State University
18548 Lyn Court
Homewood, IL 60430

Carol Slinger
Marian College
3200 Cold Spring
Indianapolis, IN 46222

Joe Smith
Northern Kentucky University
35 Kathryn Avenue
Florence, KY 41042

Judy Sowder
Department of Mathematical Sciences
Northern Illinois University
DeKalb, IL 60115

Larry Sowder
Department of Mathematical Sciences
Northern Illinois University
DeKalb, IL 60115

Kenneth Stilwell
Mathematics Division
Northeast Missouri State University
Kirksville, MO 63501

William Stokes
Austin Peay State University
316 Irene Drive
Clarksville, TN 37043

Jane Swafford
Northern Michigan University
Marquette, MI 49855

Nancy Taitt
Department of Mathematics
Eastern Illinois University
Charleston, IL 61920

Diane Thiessen
University of Northern Iowa
1929 Olive
Cedar Falls, IA 50613

Linda Thompson
Carroll College
W 253 S 6750 Longview Drive
Waukesha, WI 53186

Kenneth Travers
University of Illinois
341 Armory
Urbana, IL 61801

Arnold Veldkamp
Mathematics Department
Dordt College
Sioux Center, IA 51250

Edward Vondrak
Indiana Central University
8219 Burn Court
Indianapolis, IN 46217

August Waltmann
Wartburg College
2100 12th Street N.W.
Waverly, IA 50677

Avrum Weinzweig
University of Illinois - Chicago
Box 4348
Chicago, IL 60680

Donald Whitaker
Mathematical Sciences Department
Ball State University
Muncie, IN 47306

Richard Wilders
North Central College
Naperville, IL 60566

Bruce Williamson
University of Wisconsin - River Falls
River Falls, WI 54022

John Young
Southeast Missouri State University
3231 Lakewood Drive
Cape Girardeau, MO 63701

Norman Young
Concordia College
45 Franklin Avenue
River Forest, IL 60305

Monica Zore
Marian College
3200 Cold Spring Road
Indianapolis, IN 46222